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PIPE LINE INDUSTRY

AUGUST
1958

Publishing Company, 1958

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SERIAL RECORD
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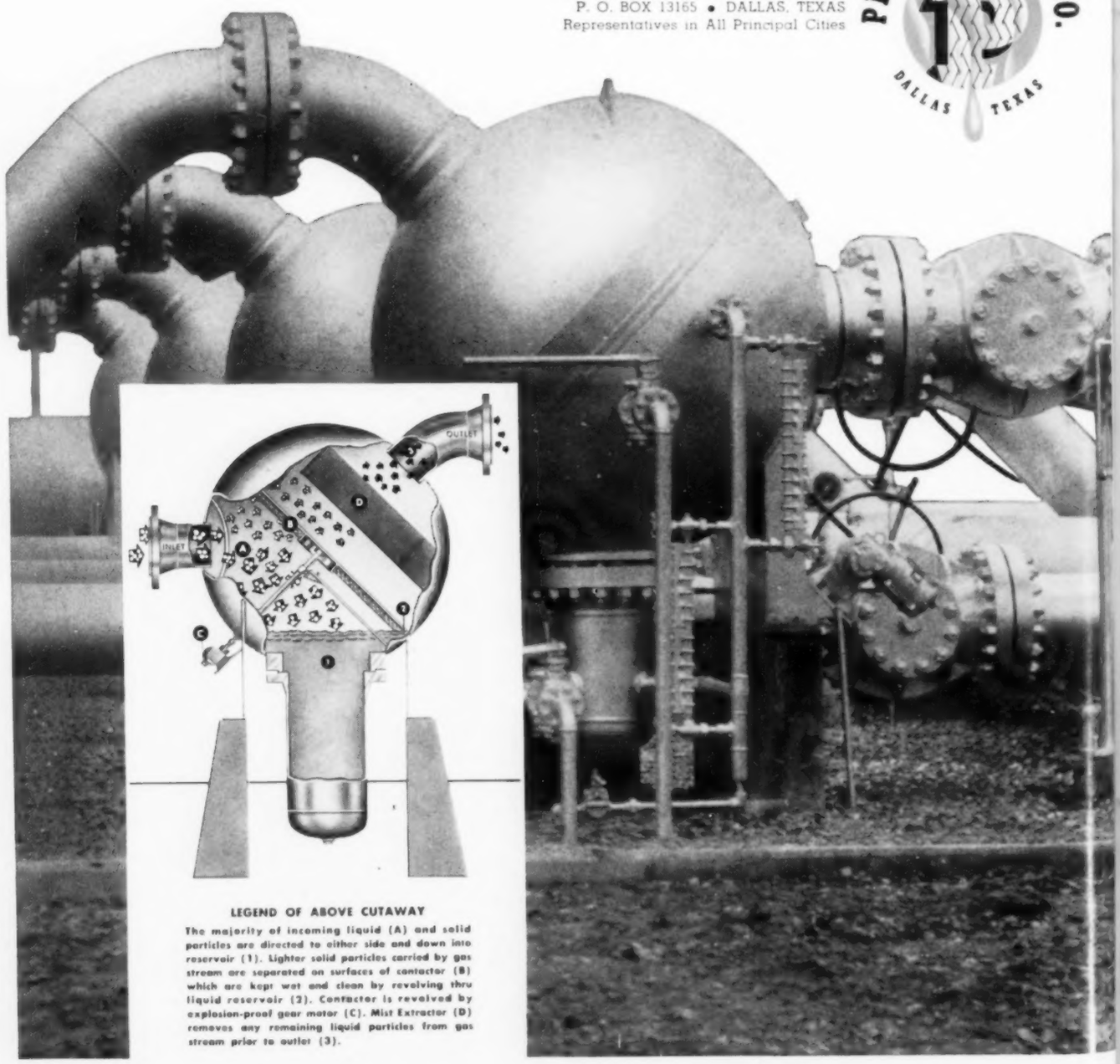

LEGEND OF ABOVE CUTAWAY

The majority of incoming liquid (A) and solid particles are directed to either side and down into reservoir (1). Lighter solid particles carried by gas stream are separated on surfaces of contactor (B) which are kept wet and clean by revolving thru liquid reservoir (2). Contactor is revolved by explosion-proof gear motor (C). Mist Extractor (D) removes any remaining liquid particles from gas stream prior to outlet (3).

AUG 19 1958

PIPE LINE INDUSTRY

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August, 1958 Vol. 9, No. 2

To help you put first things first, scan these time-saving digests, checking ☑ those you want to read first.

Rupture Control Monitor Guards PG & E's Main line

☐ To safeguard the security of its 34-inch line that serves the bulk of northern California's gas demands, Pacific Gas and Electric Company engineered an extensive rupture control system to detect and isolate a line break. Latest refinement is a two-tone transponder alarm monitor that will locate any valves closed for rupture control and report them to attended stations using pulse coded data over the operating telephone circuit.

By James H. Stannard, Jr., and Tod Morcott ..... Page 22

Using Hydraulic Triangles for Pipe Line Design

☐ First step in pipe line design is determination of line size and the number and location of booster stations. Here is a review of the graphic method of solving hydraulic problems based on hydraulic gradient triangles.

By L. Hawkins and F. D. Edwards ..... Page 28

Gas Storage Well Deliverability Boosted by Fracturing

☐ Underground gas storage field operators are finding the economics of hydraulic well fracturing of real interest. Higher deliverability may often postpone the need for drilling additional wells or adding a field to meet service demands. Most storage fields may be stimulated by fracturing through proper well selection and completion practices.

By A. B. Waters and H. J. Ayres ..... Page 32

Eliminating Explosions in Starting Air Lines

☐ Many of the potential explosion hazards in starting air lines for compressor engines are being eliminated by good design and maintenance practices, but complete elimination of all dangerous conditions is difficult. A survey of 53 stations operators points up the successful use of fire resistant lubricants and thorough chemical cleaning of air lines to remove the major source of explosion propogation.

By Robert S. Ridgway ..... Page 38

Aramco Protects Middle East Pipe Lines

☐ Soil resistances on Aramco's pipe line system vary from 800,000 ohm-centimeters to as low as 5 ohm-centimeters. In desert areas lines pass through depressions called sabkhas where highly saline waters are at or near the surface. In addition, much of the system is in coastal water of the Persian Gulf. Aramco is solving their corrosion problems using rectifiers, magnesium anodes, diesel generators, welding machines, and a windmill.

By Edward G. Peattie ..... Page 42

Thinking—An Elusive Art

☐ For some time there has been a growing concern that too many industry executives are reluctant to think. Here are the reasons why, plus some think "stimulators" that will stretch your reasoning power to the limit. You can test your thinking ability—so be sure to read this article ..... Page 48

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PIPE LINE INDUSTRY published every month. Entered as second class mail matter July 9, 1954, at the post office at Houston, Texas, under the act of March 3, 1879.

Let's be thankful for an oil surplus

TODAY A BIG SURPLUS of oil exists in the Free World. It is possible to produce far greater quantities than are needed. Tomorrow, however, it may be difficult for the Free World to provide enough oil to fulfill all its needs. Such a drastic change could take place overnight.

This tremendously important and dangerous uncertainty hangs over the head of the oil industry of the Free World, and therefore also over the head of the military, industrial and civilian might of all Free World nations because of the current grave Middle East crisis.

No one can be sure we are not on the very brink of war, which would require tremendous quantities of oil. Even short of war, the accessibility of Middle East oil to the Western Powers is jeopardized by events of recent weeks in the Middle East.

ARAB NATIONALISTS at any moment can easily stop the movement of much of the Middle East's oil to Western powers. Particularly easy to stop would be shipments made through pipe lines to the Mediterranean Sea.

Approximately 900,000 barrels of oil moves daily via pipe lines to the Mediterranean, 540,000 barrels from northern Iraq fields across Iraq, Syria and Lebanon, and an additional 360,000 barrels per day from Saudi Arabia across Syria and Lebanon. A handful of hot-headed Arab Nationalists, with or without the approval of their leaders, could easily blow up these pipe lines at will, as was done during the Suez Canal crisis.

If only that Middle East oil normally shipped by pipe line to the Mediterranean is shut off, Western powers would not experience much difficulty replacing it. At least a large part of the Saudi Arabia production now shipped by pipe line could be rerouted to move by tanker from Persian Gulf ports as long as the Suez Canal is open to Western tankers. The West could be deprived of production from northern Iraq if these pipe lines are blown up. Iraq oil must move overland. However, Western powers could easily replace this relatively small amount of producing from the surplus producing capacity in the U. S. and Venezuela.

Blowing up of the Iraq and Saudi Arabia pipe lines might prove more of a disadvantage to the Arab Nationalists than to the Western powers. Stoppage of Iraq production would deprive the Iraqi Nationalists of the country's principal source of income. Iraqi need for Western money may be greater than the West's need for Iraq oil.

IF THE SITUATION becomes more intense, and Western troops become involved in fighting, Nasser might decide to retaliate by closing the Suez Canal. This would deprive Western powers of most of the 4 million barrels of Middle East oil they are now consuming each day. Closing of the Suez Canal would impose a much more difficult situation on the Western powers. However, it would also pose difficult problems for Nasser.

Closing of the canal, would create terrific financial burdens on Egypt. Canal tolls are one of the principal sources of revenue for the country. Approximately 1.8 to 2.0 million barrels of Middle East oil moves to market, principally in Western Europe, every day through the canal. Nasser also would be defying treaty obligations, and he might create the enmity of Saudi Arabia, Kuwait and Iran because he would be stopping their chief sources of income.

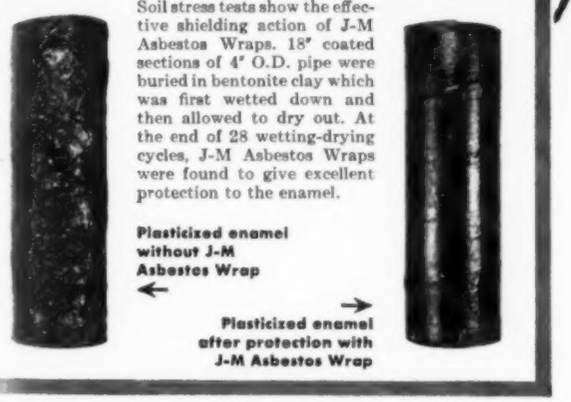
If the Suez Canal is closed to tankers, there would be an oil shortage in Western Europe, as there was in late 1956 and 1957 when the canal was closed. The U. S. and Venezuela again would be hard pressed to furnish enough oil to keep Western Europe plants in operation. Rationing again would be necessary in some Western Europe countries.

Come what may, the U. S. oil industry again, as many times before, stands ready to place a considerable surplus producing capacity at the disposal of the nation and its Allies. Thanks to the stimulus provided by this country's competitive business system, a sizable surplus producing capacity once again has been developed in the U. S. during the past decade. Let's be thankful this country has a surplus of oil. It may come in very handy—soon.

Warren L. Baker

Stop damage to enamels from earth loads and soil movement . . .

Johns-Manville Asbestos Wraps are available in 3 types for field application or mill wrapping.



Soil stress tests show the effective shielding action of J-M Asbestos Wraps. 18" coated sections of 4" O.D. pipe were buried in bentonite clay which was first wetted down and then allowed to dry out. At the end of 28 wetting-drying cycles, J-M Asbestos Wraps were found to give excellent protection to the enamel.

Plasticized enamel without J-M Asbestos Wrap ←

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Get lasting protection with tough, strong J-M Asbestos Wraps

Extensive research and field tests conducted by a leading firm of consulting engineers have demonstrated the effects of soil movement and earth loads on pipeline enamels. They show how the forces of the soil tend to distort and induce thin spots that weaken the protective coating . . . permit corrosion of the pipeline.

The same research and field tests also demonstrated that J-M Asbestos Wraps provide the strong protection that strong coatings need and deserve. "Asbestos Wraps offer the most effective single protection against damage—prolong the working life of pipeline enamels." Here's why . . .

Asbestos is an ageless mineral. Fibers of asbestos are strong and tough . . . cannot rot or decay. As used in J-M Wraps, the fibers are felted, then impregnated with a coal tar or asphalt saturant to form literally a flexible covering of stone. These "stone-like" qualities form a durable shield—protect pipeline enamels from earth loads and soil movement which weaken coatings and permit pipe corrosion to set in.

Pipeline engineers are invited to write for their own copy of PP-34A, a *3-Point Study of Pipeline Coatings and Wrappers*, at no cost or obligation.

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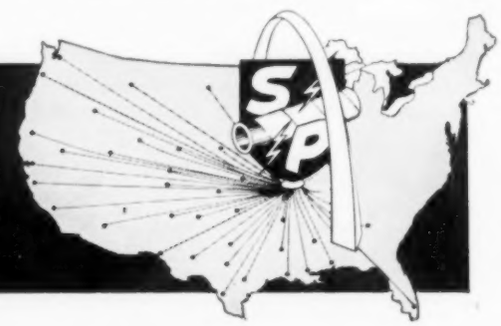

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Indexed by Engineering Index

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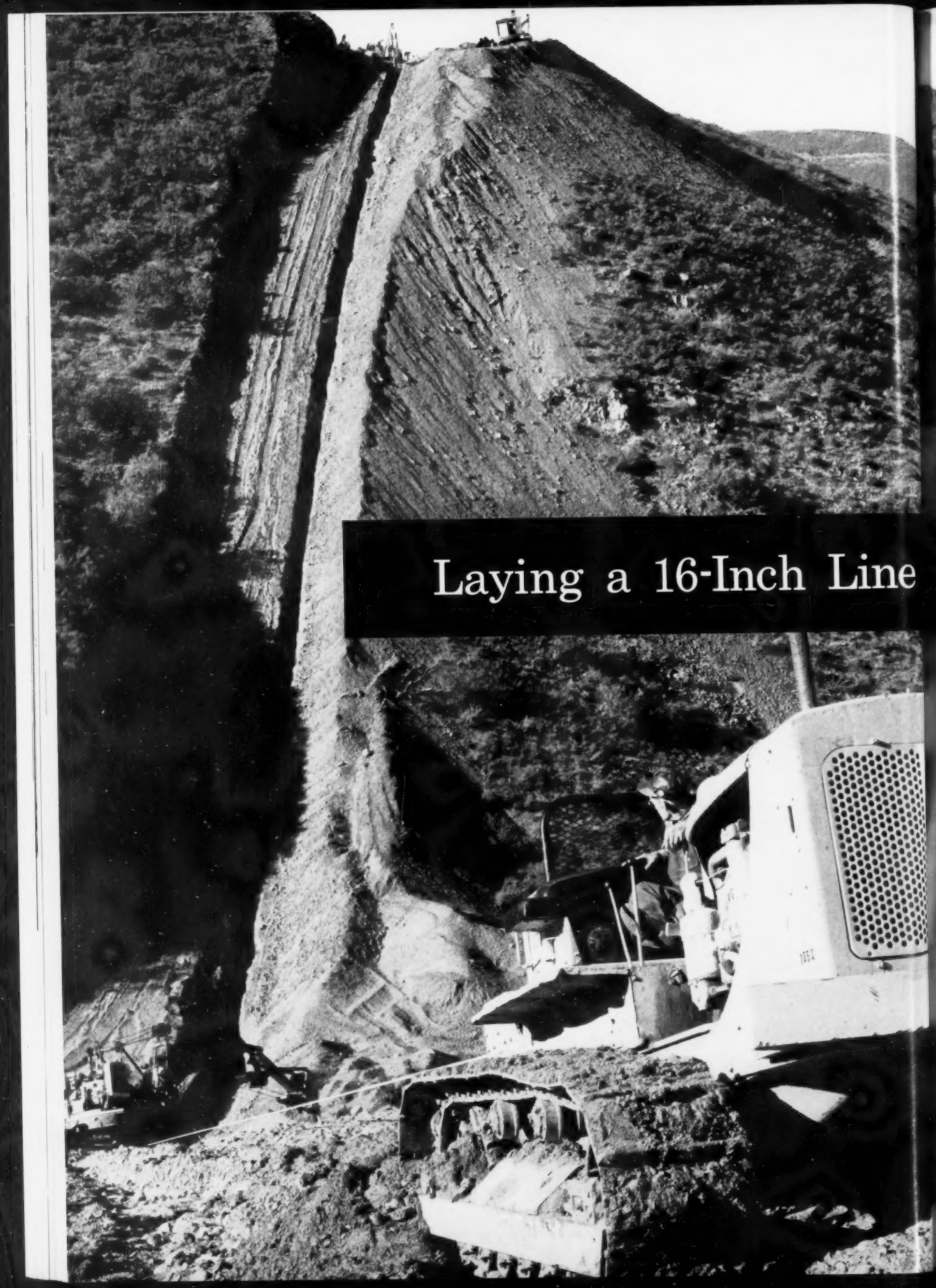

Laying a 16-Inch Line P

FIRING LINE — Two MD7s raise the pipe for welding. On the job is a Cat Twin Arc-Welder mounted on a D7 while a D6 pulls another welder mounted on a track wagon.

CAT NO. 583 PIPELAYER AND MD7 with adjustable counterweights team up for R. H. Fulton for doping and wrapping near Twenty Nine Palms, Cal.

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R. H. Fulton put 165 men and a Caterpillar spread to work on Section 5, where young mountains and 80% slopes had to be crossed

Winching is a standard operation on Section 5, part of a 635-mile crude oil line from Farmington, N. M., to Long Beach, Cal. Experienced pipeliners report that this section has some of the roughest terrain they ever encountered. Using a spread of Caterpillar equipment, R. H. Fulton & Co. is laying 2 miles each 10-hour day on their portion of the line.

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Filling out the spread on this section are four Cat Twin Arc-Welders, nine Pipelayers and a No. 12 Motor Grader.

On the toughest pipeline jobs throughout the world, Caterpillar yellow is always the predominant color of the equipment. Pipeliners know from field experience that wherever the pipe takes them, Caterpillar equipment will get them through.

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MAN-SIZED PIONEERING — Two giant D9s bulldoze and rip the rocky soil for the ditcher. One D9 is equipped with a Kelley Ripper while the second uses a matching No. 9 Ripper.

A LIFT FROM A D7 — A backhoe is winched up a 75% grade by a D7. Atop the hill in the back are two D8s with a winch and a Caterpillar MD7 with a pneumatic drill.

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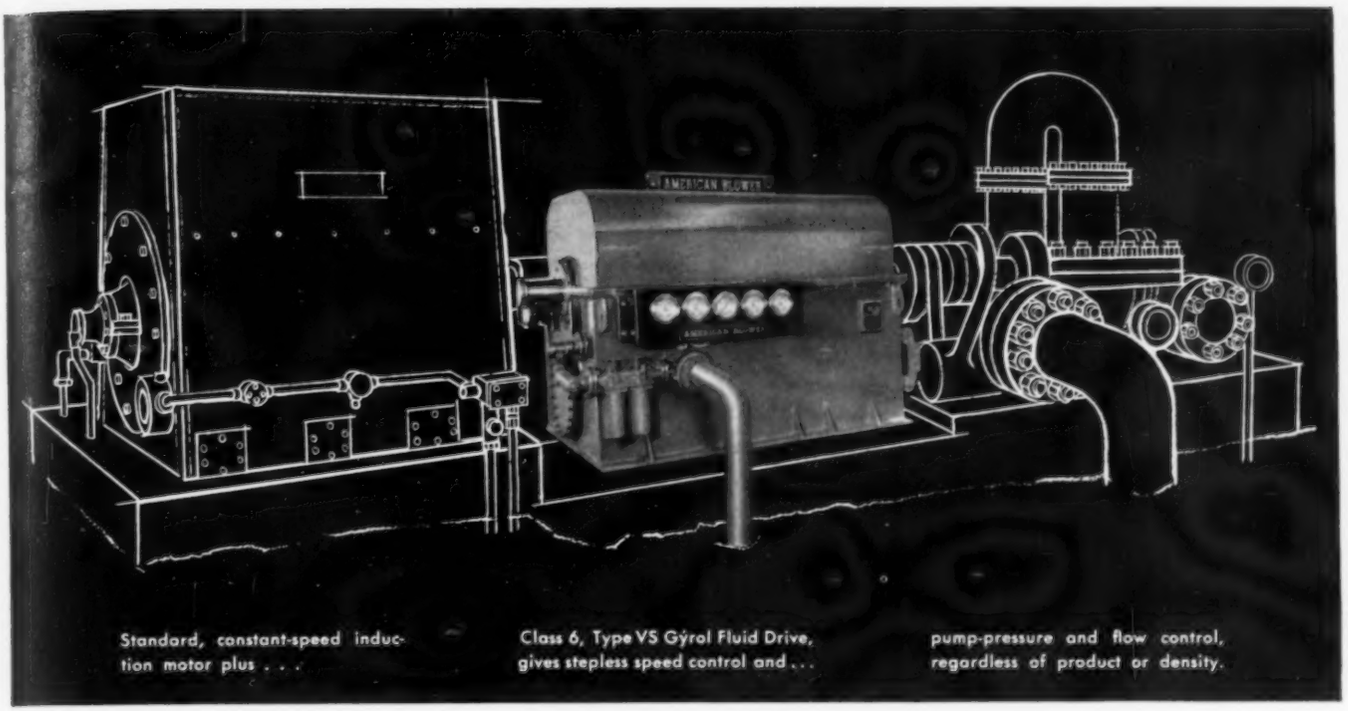

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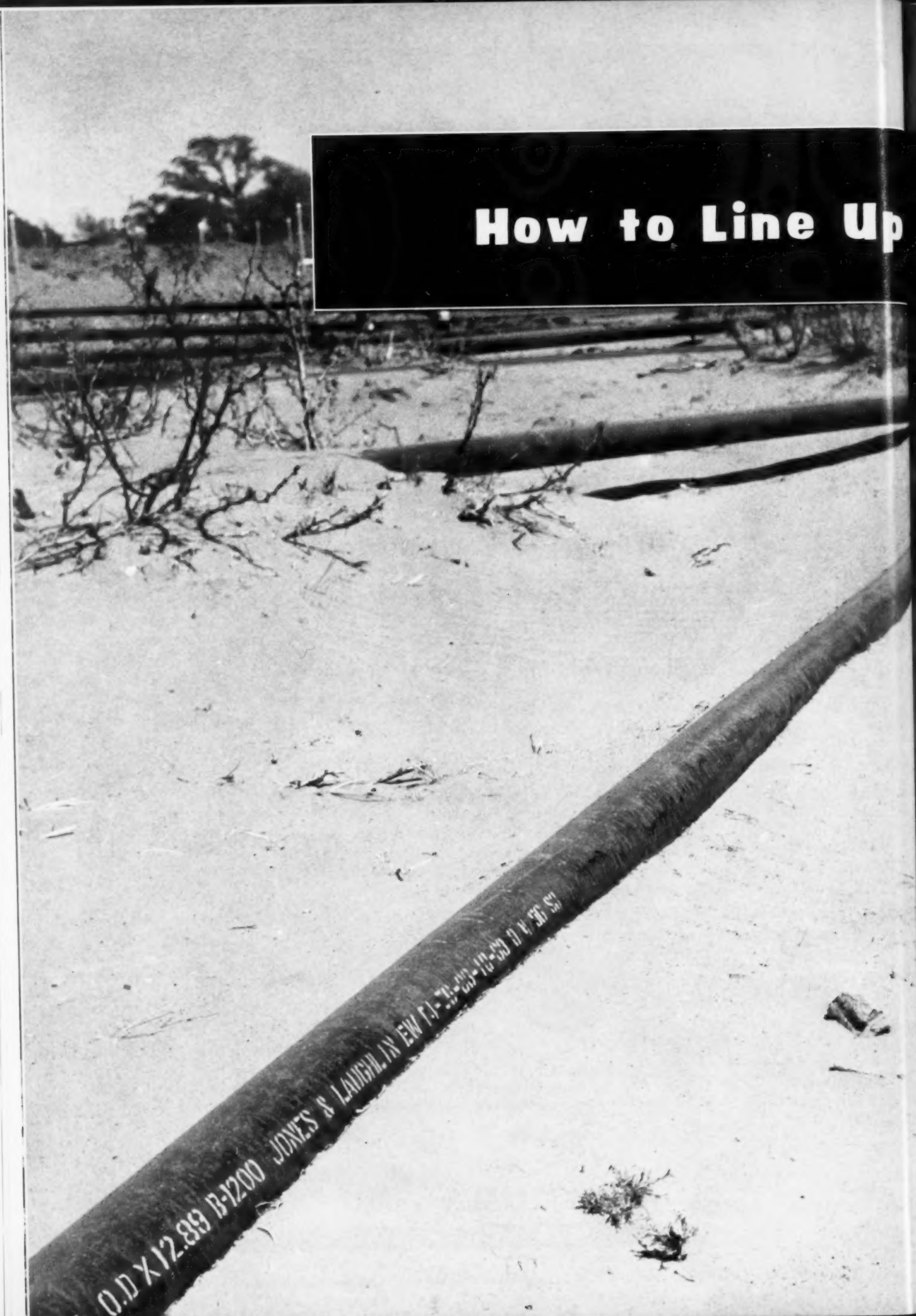
How to Line Up P



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For more data on advertised products, use Readers' Service Cards, last page.

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Tuffy Slings swung the "hefty" parts of this huge hydraulic press into position and then handily picked up the whole assembly to load it out for delivery. The secret of the amazing strength of all Tuffy Slings is their special purpose steel and the way it's machine-braided to give a combination of toughness and flexibility you won't find in any other sling.

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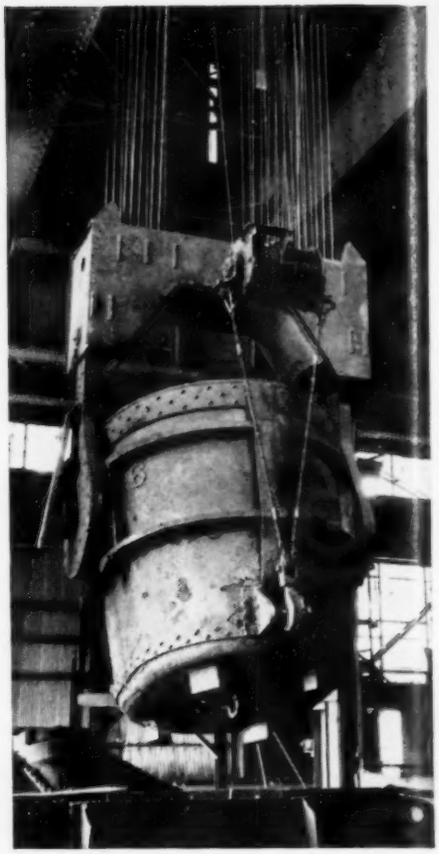
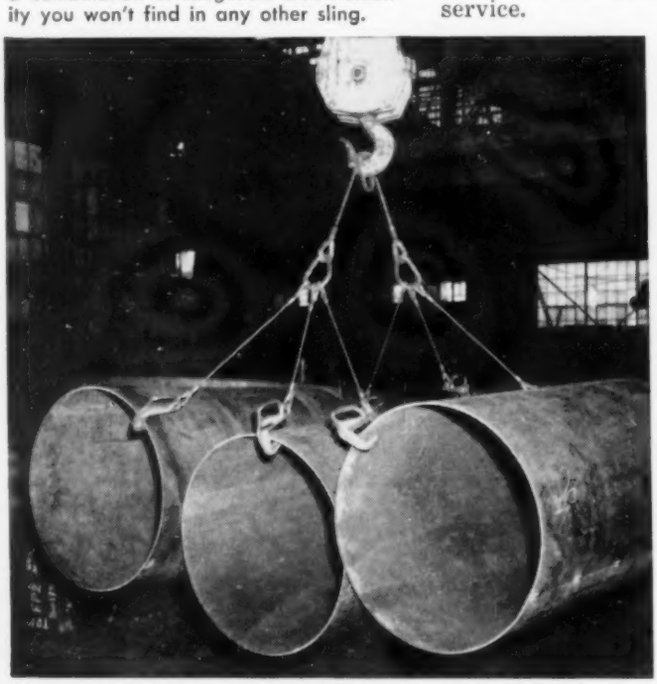
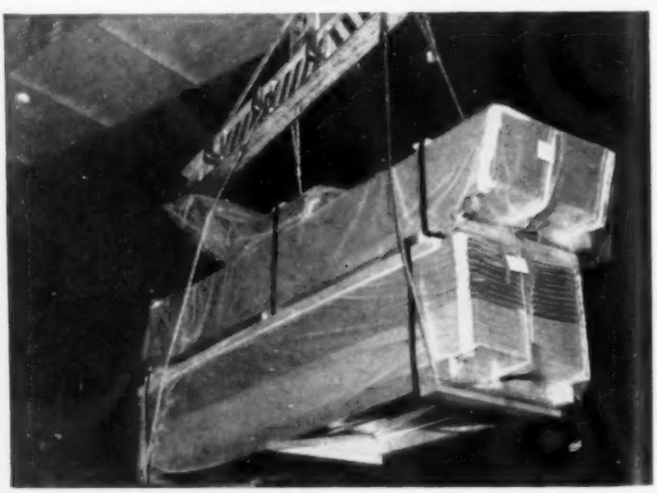


Tuffy gives steel mill TWICE the service! Quoting a giant steel corporation: "We are getting double the service life from our 1¼" Tuffy Slings as we did from 6 x 37 type slings." Reason: ideal balance of strength and flexibility in Tuffy Slings. Pictured: Huge ladle, pouring tons of molten steel into furnace, is handled by a 1¼" Tuffy Sling and two 1⅛" Tuffy Hoist lines.



Three ride where one rode before! A Canadian iron works makes tanks on production-line basis. Plate steel is rolled into 8'-long tank sections, then transported by overhead crane to final assembly point. The sections used to ride suspended on a chain — one section per trip. A better idea was presented. Now a rigging of U-9 Tuffy Slings with pipe hooks handles all three sections of a tank in one crane trip.



Buildings aweigh! One of the nation's largest makers of prefabricated steel buildings speeds up production with Tuffy Slings. High flexibility makes Tuffy Slings conform perfectly to irregular load contours, hug sharp corners and snug down smoothly in a basket hitch. Handling and rigging time are cut to the bone.

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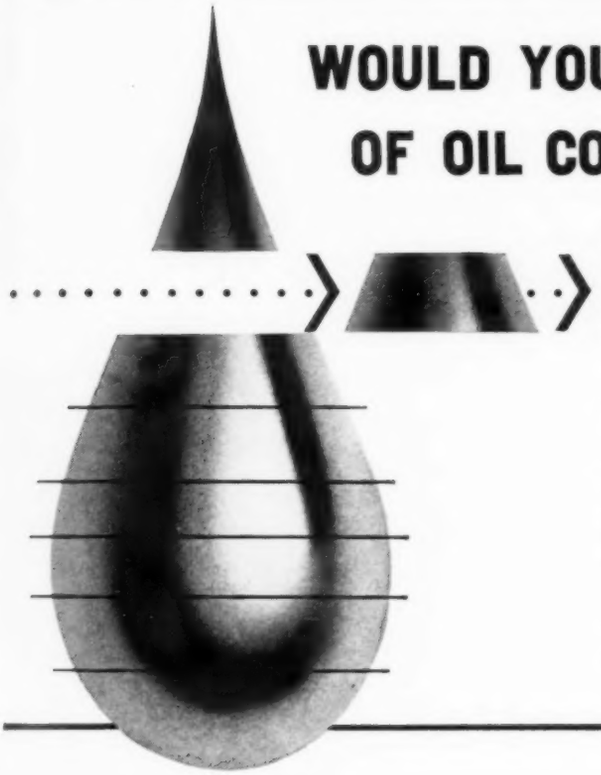

Take a 12 cylinder, 2,000 HP, 330 RPM engine . . . let just **ONE-EIGHTH OF A DROP** of additional oil per stroke be used in each cylinder and here's what will happen: your oil consumption rate will increase from 8000 BHP hours per gallon to 2000!

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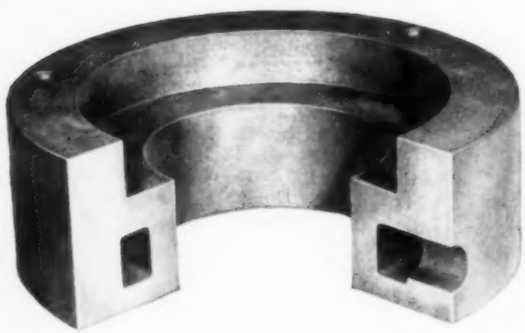

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Full-time schedule-beating TD-24 exclusives!

Midwestern beats soft going with TD-24's exclusive margin of flotation—up to 18% less weight psi on the tracks than other crawlers exert! Exclusive TD-24 Planet Power steering assures full-time "live" power on both tracks—to turn smoothly with heavily-loaded boom.

Exclusive TD-24 fingertip hydraulic braking and foot decelerator give precision pipe-carrying control. Exclusive spread-speeding, on-the-go TD-24 Hi-Lo shifting gives fingertip matching of speed to load—avoids delay, increases production. Exclusive reach-easy controls in vertical cluster, add operator convenience and control accuracy!

Add up these and all the other big, full-time pipe-handling exclusives you get in an International Superior TD-24 sideboom. See how these performance features increase capacity, reduce downtime, boost manpower efficiency. And compare how bonus-powered TD-18, TD-14, and TD-9 sidebooms also out-perform all other crawlers in their size classes. See your International Superior Distributor for a demonstration of the boom and tow equipment you need.

Here are four of "Midwestern's" TD-24 sidebooms lowering-in, on a stretch of the Morris-to-Chicago g line. "I've had TD-24 booms since '53," states E. Wolfe, lowering-in foreman. "I like the TD-24 b cause it gathers up a lot of this big pipe, and su is easy to operate."

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View below shows the TD-24 cradling for the CRC doping machine, which is powered with an International U-372 engine. "In all my 30 years of pipe-laying operations, I find the International TD-24 boom tractor the most advanced and best balanced I ever had," states spread superintendent, John Works.

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PIPE LINE PANORAMA

Outlook Brightens for Pipe Line Construction . . . After discouraging period of Memphis Decision and recession-created "doldrums," letting of pipe line contracts took sudden surge upward last month. Between middle and latter part of July, 1920 miles of contracts were let—more than double 800-mile average of previous six months. (See Page 55). Major projects include Southern Natural, 516 miles; Natural Gas, 511; Wabash, 265; Eastern Shore, 145; Shell, 62; Gulf Interstate, 54.

Synthetic Lubricants Curb Air Line Explosions . . . Natural gas industry has been trying for several years to prevent explosions which infrequently occur when starting large internal combustion engines with compressed air. Studies are now paying off: Synthetic lubricants have been developed that could end such accidents. Used only after air supply lines have been thoroughly cleaned of oil, carbon, scale and rust with a hot detergent, several operators report explosion-proof mixtures are producing excellent results. (See Page 38.)

Pipe Line Corrosion Costs $600 Million Per Year . . . National Bureau of Standards has just released highly informative report on more than 40 years of underground corrosion research. Some of the findings: U. S. pipe line industry spends $600 million annually to protect lines and equipment from corrosion—approximately one million miles of oil, gas and water lines are now criss-crossing the U. S.; also about 170,000 miles of other buried structures (cables etc.).

Fracturing Increases Efficiency of Gas Deliveries . . . Several companies are taking a closer look at hydraulic fracturing treatments for gas storage wells to decrease injection pressures and to increase withdrawal rates from reservoirs near major consumption areas. Result: deliverability efficiency is increased, without the cost of drilling more wells to meet growing gas demand. (See Page 32).

World's Largest Diameter Gas Line Under Construction . . . Carnegie Natural Gas' 25-mile line that will carry coke-oven gas stabilized with natural gas to U. S. Steel mills along Monongahela River near Pittsburgh, is slated for completion early in 1959. Line will consist of 16-miles, 55⅜-inch and 9-miles 43¼-inch line.

Unusual feature of project: Mining methods were used in boring road crossings (See May PLI, Page 61). As casing was forced under roadbed, miners excavated dirt and rock from face of the bore with conventional mining tools.

Washington Panorama . . . As of August 1, pipe line companies will start cashing in on recent repeal of 4.5 percent federal tax on pipe line shipments. Unexpected Congressional action brings welcome break in steadily mounting costs that have been slicing into industry profits the past few years—**Recently vetoed effort of CATC Group** to sell 175,000 Mcf/d of offshore natural gas to Tennessee Gas Transmission for 22.4 cents per Mcf may still have another chance. Federal Power Commission has petitioned Federal Court of Appeals to hold rehearing on its previous order which whittled price to 18 cents per Mcf from 22.4 cents granted in FPC in June 24, 1957—**FPC's newest member,** former Louisiana Commissioner of Conservation John B. Hussey, is something new in the way of that agency's appointees. He has had several years of experience in oil industry affairs. He is pro-oil, against utility-type control of natural gas, for voluntary import controls, strongly opposed to growing federal control of industry.

Rupture Control Monitor Guards PG & E's Main Line

Electronic "watchdog" signals attended control points if pressure limiting stations or line rupture valves sense a line break. Two-tone transponder alarm system utilizes pulse code data over the telephone circuit.

By James H. Stannard, Jr.,
Pacific Gas and Electric Company, San Francisco
and Tod Morcott,
Sierra Electronic Corporation, Menlo Park, Calif.

WITHIN A few years after completion of Pacific Gas and Electric Company's "Super Inch," pipe line some 70 percent of all of the gas supplied by the company and almost all of the gas demands of the populous San Francisco Peninsula was being delivered by this 500-mile artery. Security of the pipe line is of paramount importance.

Special construction equipment capable of traveling at high speeds was purchased and located at strategic right-of-way points along with stockpiles of emergency material. Emergency procedures were established and additional mobile radio coverage was provided. All of these measures were designed to materially reduce the down time of the pipe line in the event of a serious break (See PIPE LINE INDUSTRY, September, 1955, Page 26-31).

However, there still remained the problem of detecting, locating and isolating a break. The pipe line was equipped with pressure telemetering at approximately 50-mile intervals; given time these telemeters would indicate a break if there was a line failure. However, by the time telemeter readings would have changed enough to indicate a break, considerable quantities of gas would already have been lost. There would still be the problem of locating the actual break and isolating that section of the line.

This pipe line crosses some of the most desolate country in North America; portions of the line are 75 highway miles from the nearest maintenance station. Many hours could be spent by a repair crew wandering aimlessly through the desert looking for an elusive sound or sign of a line break. Meanwhile the inventory of gas in 150 miles or more of 34-inch pipe could easily disappear into the atmosphere.

Such a loss could seriously jeopardize continuity of service to customers; it would take many hours to replace gas before the line could start delivering again. Much of the firm load in the affected area could be supported from local fields, but major re-routing and increase of local gas sendout takes many hours—even if the move has been scheduled.

Automatic Sensing of Breaks. To minimize inventory loss in case of line rupture a number of strategically located valves and "pressure limiting stations" along the line were equipped with automatic equipment that would sense a major break, initiate valve closures to isolate the ruptured section, and signal the location of the trouble to the nearest attended station. Automatic equipment to sense a

line break was not new in the industry, but many problems posed by the alarm features of the proposed system were unique.

There are two methods currently used to sense a line rupture. One method—the rate of pressure change uses a capacity tank and a small restricting orifice. A line rupture causes a rapid fall in pressure in the line, and a differential sensing device between the pipe line and the capacity tank detects this change and initiates a valve closure. The second method utilizes a line valve as a differential metering device; differential sensing devices detect either an abnormal or reverse flow and in turn initiate valve closure.

It was decided that the second method would be used; there was some concern that the rate of pressure change method might close more than the necessary valves in the system. Also there was the thought that the restricting orifice in the rate of pressure change system could become blocked; in that case normal variation in line pressures would cause inadvertent valve closure.

Many of the applicable differential sensing devices on the market are of the pneumatic controller class—either a pneumatic transmitter or self contained controller. Such a device requires a continuous supply of 20 psi gas or air. Developing an instrument gas supply can be very costly—and not to be ignored is the value of the gas continuously bled to the atmosphere. It was decided that a differential sensing device that merely opens a valve would be more desirable if such a device could be obtained.

Trip Valves Modified. After consulting with the manufacturer's engineer's it was determined that modifications could be made which would improve the accuracy of the differential trip valve, for use on the P.G.&E. monitoring system. After some minor difficulties were eliminated, the trip valve proved to be entirely satisfactory.

Selected line valves were equipped with a gear reducer and a pneumatic motor assembly which had been used for automatic valves at the pressure limiting stations.

A simple control system was developed to actuate the various line valves. This equipment was mounted on a pipe stand and placed in a demountable shelter for protection from the desert climate. Changes made to existing controls of the pressure limiting stations permitted the trip valves to over-ride the normal operation of the automatic pressure limiting equipment. At both the line rupture valves and the pressure limiting stations a pressure switch was provided between the trip valve and the pneumatic motor to initiate the alarm function.

Power Supply Problems. When the "Super Inch" was built, a single open pair telephone circuit was installed parallel to the line—in most places within the right-of-way itself. With the exception of commercial toll telephone service and mobile radio, this telephone line is the only communication facility for operation of the pipe line. Maintenance personnel use the physical circuit; and the telemetering, teletype and through telephone are derived carrier frequency channels.

The pipe line route from Topock, Ariz., crosses the Mojave Desert, the Tehachapi Mountains, and farm lands of the San Joaquin and Santa Clara valleys. It is subjected to some of the most violent weather in California—lightning, sandstorms, cloudbursts and temperature extremes of 0° to 140°F. There are very few places along the line close to electric power—and at many of these power is not dependable.

Electronic System Design. When P.G.&E. started its line rupture control program, a survey of available equipment was made. It was found that there were no suitable alarm systems on the market so an electronic manufacturer was asked to make the necessary studies. From research data a plan was developed with sufficient details to permit a cost evaluation of the alarm system.

Quite a bit of attention was given to various ways of using the physical

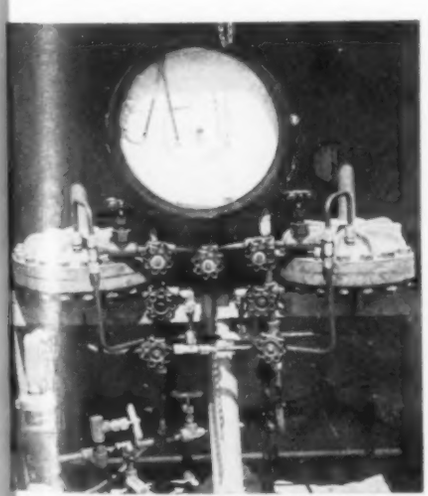

FIGURE 1a—Standard trip valves were modified to give greater accuracy in the monitoring system. Equipment is mounted on pipe stand and housed for protection from weather extremes.

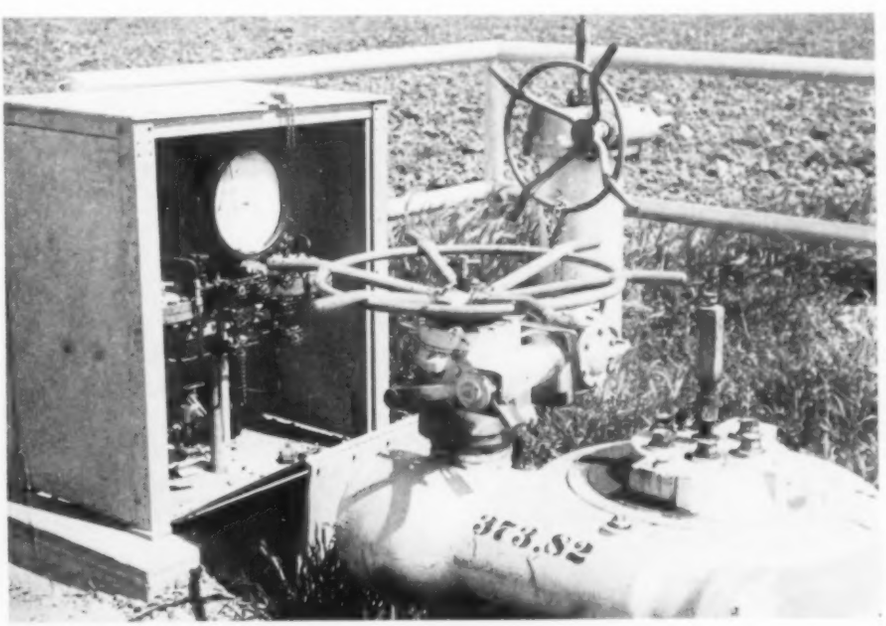

FIGURE 1b—Control system for initiating break closures of selected line valves. Changes in pressure limiting station design permits trip valves to over-ride normal operation.

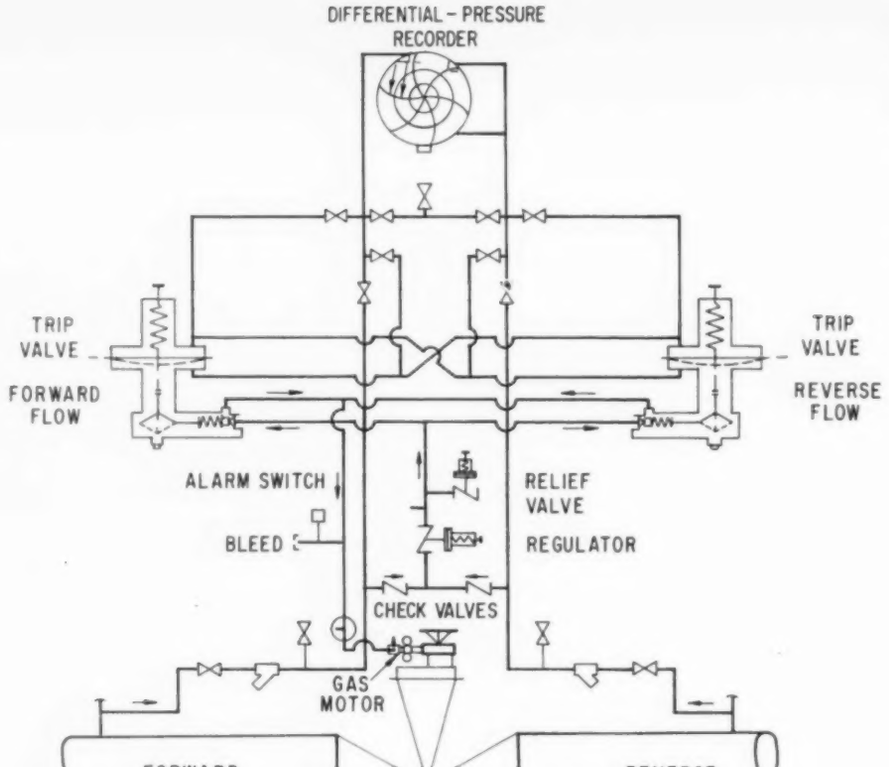

FIGURE 2—Schematic of automatic closure system. Controls for pressure limiting stations were modified to permit the trip valves to over-ride normal operation of the automatic pressure limiting equipment. A pressure switch initiates the alarm function.

circuit. Operation of the rupture alarm is of such importance that it could take priority over all other traffic on the telephone line for the short time required to transmit the coded information.

However, during hot summer months desert dust and lightning storms, which occur quite often, can charge the line. When the static charge rises to about 200 volts, protective spark gaps flash over and discharge the line. This results in low frequency saw tooth waves with harmonics up to 3 or 4 kc. Under such conditions the physical circuit is all but useless. Carrier frequency channels experience little interference during these storms so carrier signaling was chosen for the monitor system.

Telemetering Signal Choice. The simplest method for signaling would be a standard carrier frequency telemetering transmitter operated by valve closure. Each alarmed location would be assigned a different frequency. Since this requires approximately 20 telemeter channels, it would

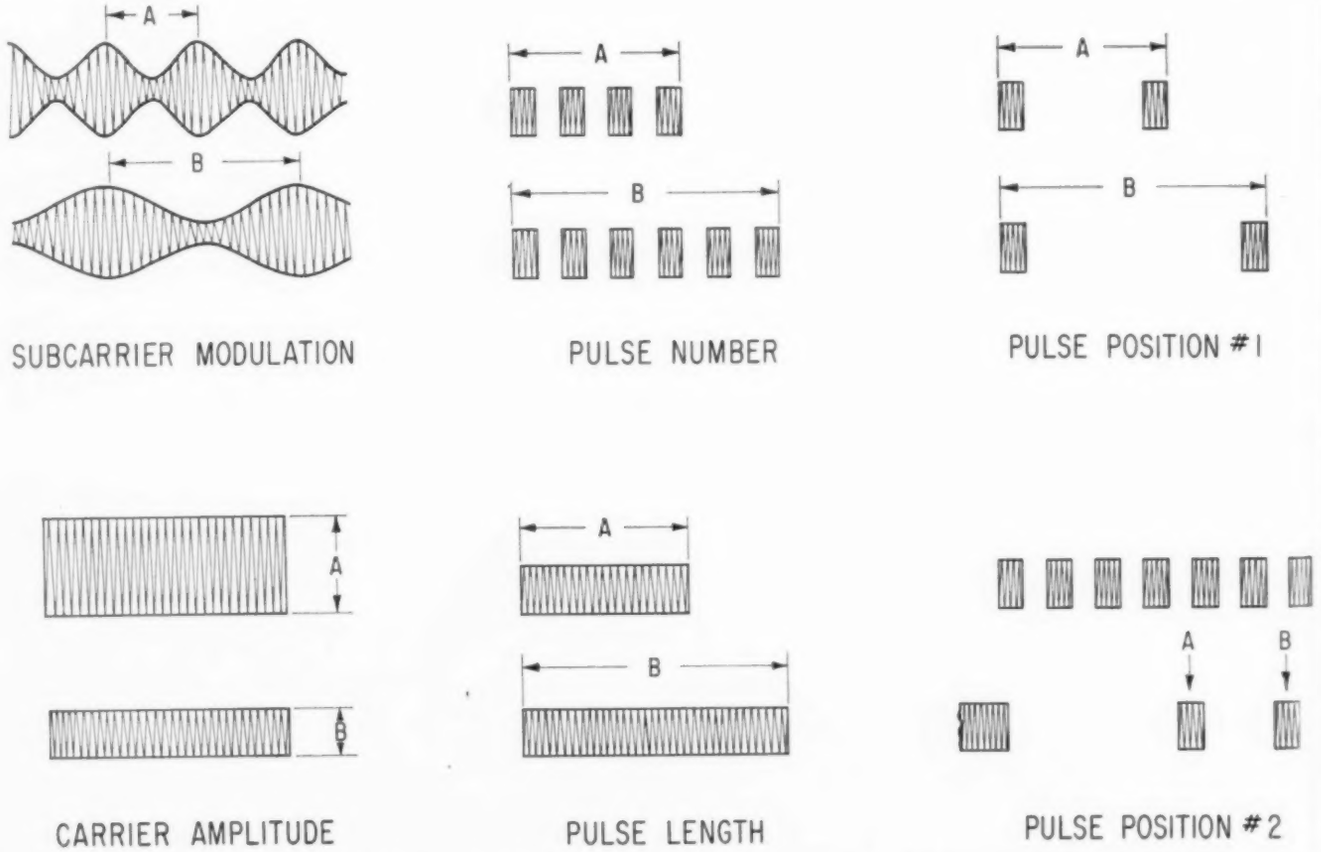

FIGURE 3—Methods considered for coding the alarm signal intelligence for the monitoring system. Carrier amplitude, although a very simple coding method, would require continuing maintenance to achieve proper levels for alarm units and would be complicated by telephone line attenuation with the weather. Pulse position coding was selected for the two-tone transponder alarm network.

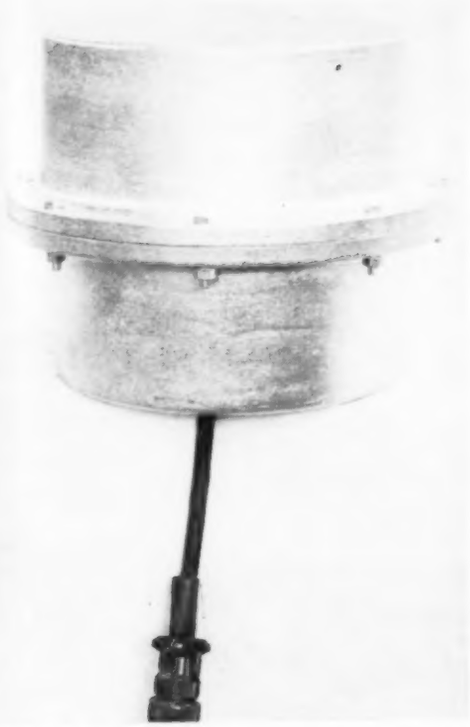

FIGURE 4a—Basic elements are enclosed in cast aluminum weatherproof mounting. Disconnect plug facilitates repairs.

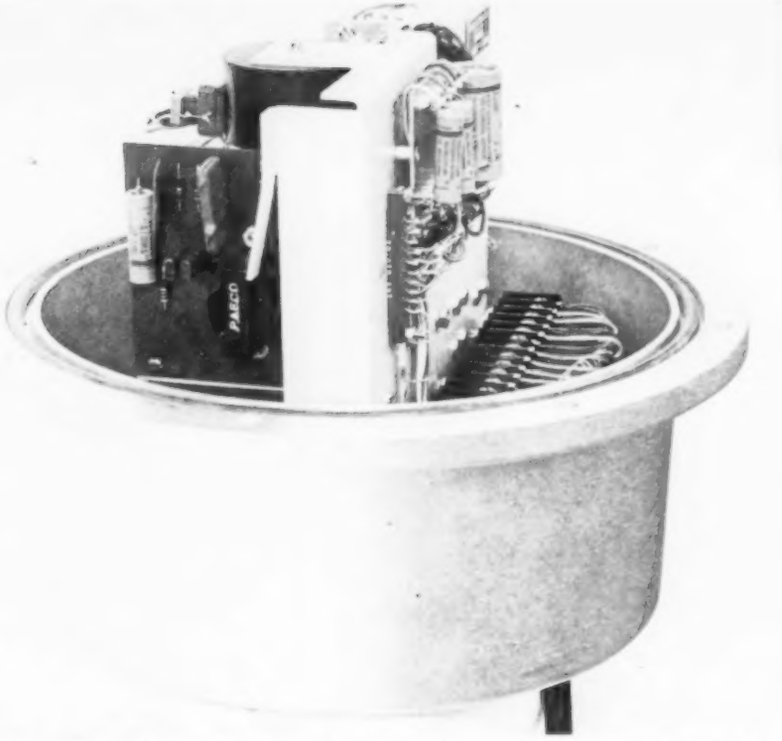

FIGURE 4b—Remote alarm unit with weatherproof cap removed. Each unit includes transistorized carrier frequency transmitter and receiver plus associated relays. Bolt down cap and rubber O-ring seal protect electronic equipment.

occupy too much of the valuable frequency spectrum on the already crowded telephone line. To conserve spectrum, some coding method was necessary.

There are two general methods used to code alarm devices. In the open ended system the remote alarm unit transmits a coded identification signal which the terminal equipment records. In the other, a transponder system, terminal equipment interrogates various alarms and only those units in an alarm condition respond.

The alarm system at the early stage of planning was a coded signal transmitted on a minimum number of carrier frequency telemeter channels having two coding systems from which to choose. The open ended system is by nature the simplest, but it has two serious disadvantages. If two valves were to be activated about the same time, their signals might interfere and give a false indication; or, if the pipe line ruptures, the telephone line might at the same time be damaged by flying debris, thereby causing interruption to the signal.

P.G.&E.'s transponder system is made free from mutual interference by giving the terminal operator an opportunity to re-check his data in the event of simultaneous operation of the remote equipment. However, it has the disadvantage of being more complex.

Selecting Code Method. Interlocked with the choice of the general system is the method of coding the information.

Several coding methods are applicable to this particular problem: sub-carrier modulation, carrier amplitude and pulse coding. Sub-carrier modulation is frequently used in commercial supervisory control systems. However, it has the disadvantage of requiring as much frequency spectrum as individual carrier frequency telemetering sets. In addition equipment required for sub-carrier modulation is complex and costly.

While carrier amplitude is a very simple coding method, it would have required almost continuous maintenance to maintain the proper levels of various alarm units. To further complicate use of carrier amplitude coding, telephone line attenuation or loss characteristics varies with the weather.

There are three types of pulse coding in common use. The pulse number system is probably the most common, being used in the dial telephone. The number of pulses in a train indicates the function; this method is best suited for an open ended system.

The pulse length method is already in general use in the gas industry—time impulse telemetering is a form of pulse length coding. Duration of the pulse gives the coded information.

A pulse position method may be used in two ways. The time between two pulses may indicate the code; or number of pulses transmitted by the terminal equipment between two pulses may also determine the code. Transponder systems lend themselves best to pulse position coding.

Five different systems were developed to perform the specified functions. A conference was held with gas and communication engineers and it was decided that a two tone transponder system would provide the greatest reliability. The manufacturer then prepared details and specification as requested.

Remote Alarms Transistorized. P.G.&E.'s completed system consists of remote alarm units located at the line rupture valves and terminal alarm equipment at the various attended stations. Each remote alarm unit includes transistorized carrier frequency transmitter and receiver, associated relays, power supply and manual test switches. Relays, transmitter, and re-

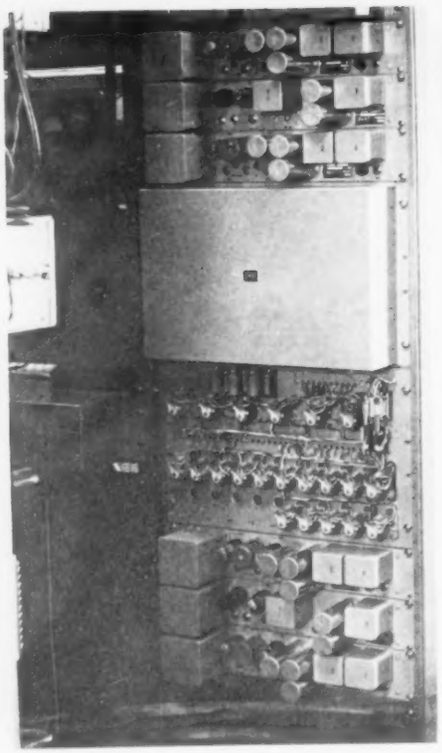

FIGURE 5a—(above) Terminal alarm equipment consists of two carrier frequency receivers, a transmitter and relay panel.

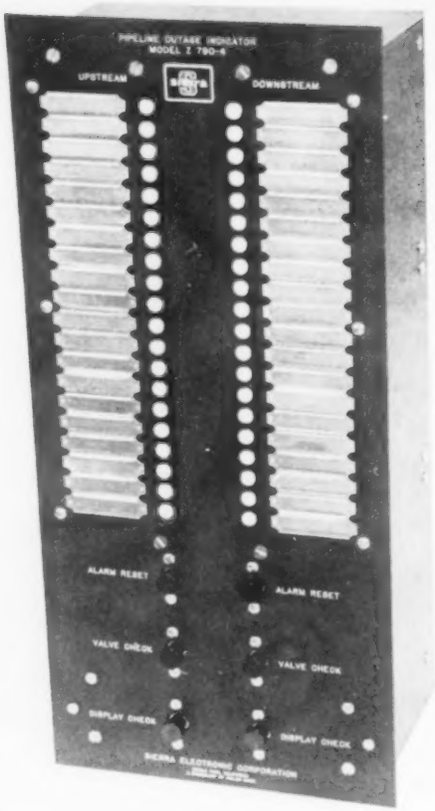

FIGURE 5b—(right) Indicator lights, alarm reset switches and test switches are located on the display panel.

ceiver are assembled in a cast aluminum weatherproof enclosure that is designed for pole top mounting.

Unit power supply and the test and reset switches are assembled in a sheet aluminum box that can be mounted lower on the pole for easy accessibility. The test and battery box also contains terminals for a portable telephone and a line bridging switch which connects the telephone terminals to the phone line.

The remote alarm unit is connected to the test and battery box with a multi-conductor outdoor service cable. This cable has a weatherproof disconnect plug adjacent to the remote alarm unit; units may be easily removed for maintenance or repair by loosening two screws and disconnecting the plug.

Carrier transmitter and receiver of the remote alarm units are mounted on individual printed circuit boards which plug into the main chassis. Transistor circuitry was employed for two reasons: low power drain and reliability. With modern production control and packaging techniques, transistors have improved to the point that their life apparently exceeds that of the other components in an electronic circuit. Transistors like other elements will change with temperature, but, as in good piping design, expansion joints or bends can be designed into the circuitry to compensate for their changes in characteristics.

Alarm Panels at Attended Stations. Terminal alarm equipment consists of two carrier frequency receivers and one transmitter plus relay and display panels.

Each relay panel contains a selector switch, control relays and holding relays; the display panel has indicator lights, alarm reset switch, and test switches. Terminal alarm units are located at each end of the line under surveillance.

How the Monitor Operates. In the event of a line rupture, a high or reverse differential is produced across the main line valve. This abnormal differential operates the differential trip valve, actuating the alarm switch and the motor driven main line valve.

When the alarm switch is closed, the line bridging relay connects the remote alarm unit to the telephone line. At the same time the carrier transmitter and receiver of the remote alarm unit will be energized; the transmitter transmits a 7.9 kc. tone. Receivers (7.9 kc.) in both the master and slave stations receive this signal and sound an alarm at both stations. When this occurs, the master station interrogates the line by transmitting a train of pulses at 7.3 kc.

Stepping switches in the master unit, the slave unit and the remote unit all step-up together. When the stepping switch in the remote unit reaches the point corresponding to its particular code, the 7.9 kc. transmitter in the remote unit, which was silenced by the first pulse of the interrogation chain, will be re-energized to mark the valve identification. Interrogation continues through the remaining points and any other remote alarm units that are energized will also respond at their corresponding codes.

If, following a predetermined time after the initial alarm, the master station has not begun its interrogation, the slave station will interrogate the line. In this case the master will become the slave if its circuitry is still sound enough. Remote alarm units that have been energized will remain connected to the telephone line for later re-interrogation until they have been manually reset.

In operation, the sounding of the alarm warns the terminal control operator, who resets the alarm and observes on the display panel which alarm function has been identified. He may then check his display by means of a valve check switch which cycles the stepping switch and repeats the identification. Had the alarm been triggered by noise, the alarm function indication does not reappear. In addition, a display check switch is available which cycles the holding relays and their associated identifying display lights to insure their correct operation.

High Reliability Achieved. Use of terminal alarm units at each end of the line under surveillance provides the equipment with a high degree of reliability; a failure of one of the terminal units, or a break in the communication link to one terminal unit will not impair the identification of the alarm function. Sufficient signal strength is employed to overcome a partial grounding of the telephone

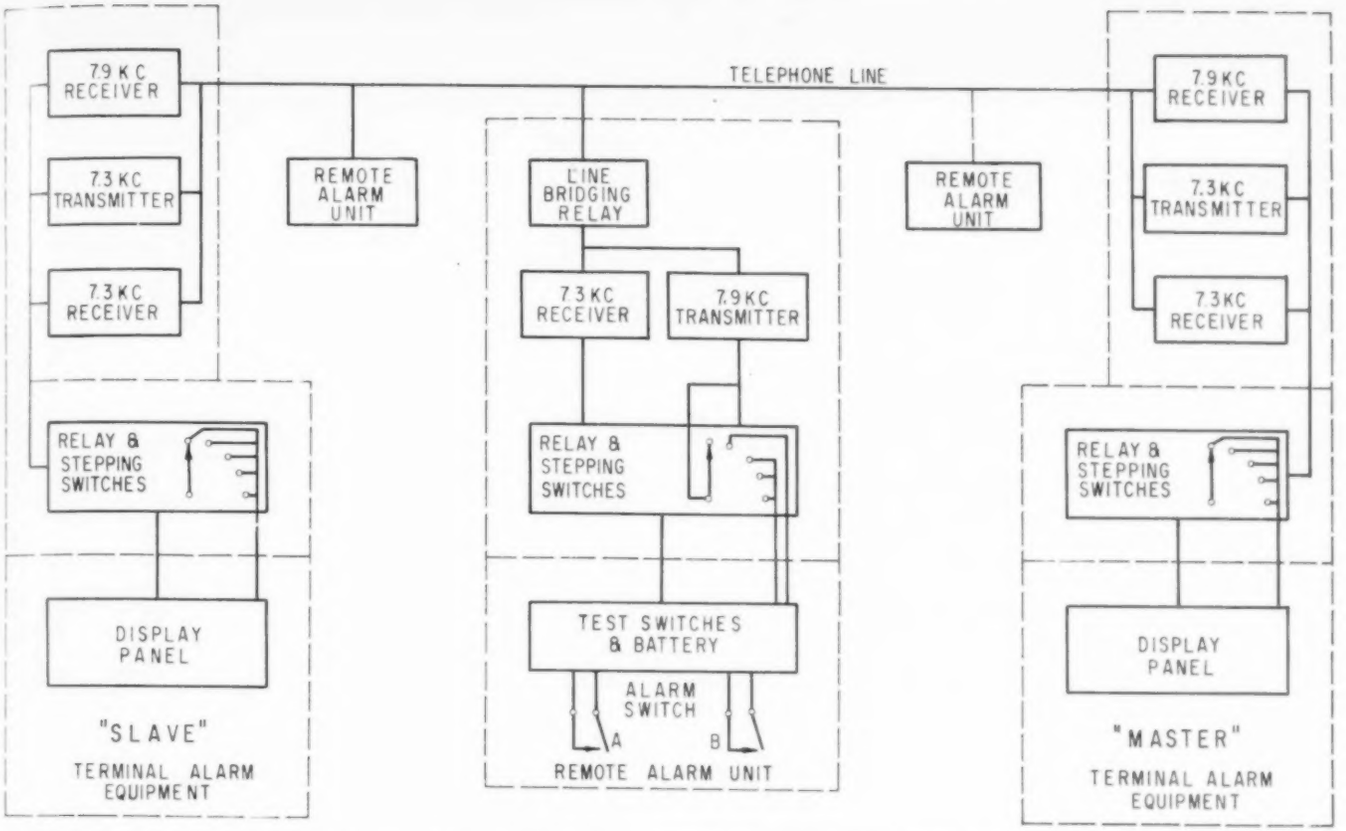

FIGURE 6—Block diagram for PG & E's line rupture alarm system. Terminal alarm units are installed at each end of section monitored.

line as might be experienced by a downed line. It is also safe from operator mismanagement; display indications can be cleared only by correcting the cause of the alarm function at its source and re-interrogating the line.

Since the remote alarm units are normally not energized, the transponder system is capable of extremely long life. When units are energized by testing or actual valve closure, the transmitter is active only during initial identification; the receiver and line bridging relay which remain energized until reset require only a very small battery drain.

Pre-Installation Tests. P.G.&E.'s line rupture alarm system incorporates many new and untried features. All individual units and the complete system were thoroughly tested in the laboratory before delivery. These tests included operation of the remote alarm units for long periods at elevated temperatures, frequency stability tests and simulated system operation.

As might be expected, a few "bugs" developed after the system was in operation. After installation, it was found that an inadvertent grounding of one leg of the telephone line could produce enough noise to cause a false alarm. One of the castings that forms the housing for a remote alarm unit was found to be porous and had permitted water to enter the unit. Solutions to these two problems have been developed and corrective measures are being taken.

So far the line rupture alarm system has only been required to function on periodic test—it is hoped that this will be its only function. However, should the need arise, it is believed that the alarm system will perform satisfactorily.

ACKNOWLEDGMENT

From a paper presented at the Pacific Coast Gas Association Transmission Conference, San Diego, Calif., May 6-7, 1958.

About the Authors

Stannard Morcott

James H. Stannard, Jr., gas engineer in the technical services group of PG&E's Gas Operations department, has specialized in the design of gas measurement and regulation stations. His duties have been primarily devoted to instrumentation, telemetering and remote control. Stannard has been with PG&E since 1947 with only a short interruption to return to college; he was graduated from Stanford University in 1951 with a BS degree in mechanical engineering. A registered professional engineer in California, he is active in the ASME and other Bay Area engineering societies; for the past two years serving as the editor of the San Francisco Engineer.

Tod Morcott, development engineer with the Sierra Electronic Corporation, has been active in the development of several of that company's electronic instruments and systems. Emphasis has been on regulated power supplies, carrier frequency systems and special equipment for snow pack measurements. After graduating from the University of California with an AB degree in physics and mathematics in 1949, Morcott served three years on the engineering staff of the University's Radiation Laboratory. He then was associated with Lynch Carrier Systems, Inc., prior to joining Sierra in 1954.

Using Hydraulic Triangles For Pipe Line Design

Here is a quick review of the hydraulic triangle method for sizing pipe lines and locating booster stations.

By L. Hawkins and F. D. Edwards
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IN DESIGNING a pipe line system, one of the first steps is to determine the line size and location of booster stations. All of the accepted formulas for hydraulic design are variations of the original D'Arcy formula. The only empirical factor involved is the friction factor reflecting the relative roughness of the interior pipe wall. In order to allow for increased roughness factor and consequently increased losses due to friction over a period of time, the fouling tendency of the fluid to be pumped must also be known. Data on these factors are fairly well established; it is possible to estimate the roughness factor and the expected increase with reasonable accuracy.

One Station System . . .

Design of a comparatively short pipe line system with no booster stations is essentially one of economics. As an example, assume a line from *A* to *B*, a distance of five miles, to handle 25,000 barrels of gasoline over a 12-hour period daily. The first step is to accurately determine the lateral distance and the elevation of *B* relative to *A*, which in this case is 25 feet. Using an accepted fluid flow equation and a suitable friction factor for the pipe, the head loss due to friction is calculated over a range of pipe sizes. All flow calculations in the following examples are based on the Beale & Docksey formula:

$$\Delta H = 8 \left(f \right) \frac{LV^2}{D\,2g}$$

Where ΔH = Head Loss in ft.
L = Length of pipe in ft.
D = Diameter of pipe in ft.
V = Velocity in ft./sec.
g = Gravitational force 32 ft./sec.^{2}

The function f varies as the degree of turbulence, pipe size, and pipe wall finish.

The degree of turbulence is given by the Reynolds No.

$$\frac{D\,V\,\rho}{\eta}$$

Where ρ = Density of Fluid in lbs./cu. ft.
η = Viscosity in F.P.S. units

f is then derived from Empirical Charts taking into consideration the Reynolds No., pipe size and wall finish.

Applying the known facts, the following items were calculated (Table 1.)

- Friction loss for 1,220 gpm plus static head of 25 feet
- Brake-hp of prime mover at 60 percent efficiency
- Cost of line installed—amortized over 10 years
- Estimated attendance and maintenance necessary per year
- Power costs per year—based on 1 cent per kwh
- Total cost per year

TABLE 1—Installed Cost of Pipe Line and Pump Station for Five-Mile System

BASIS 25000 BBL GASOLINE / DAY. 50% OPERATING TIME = 1220 G.P.M.
DISTANCE 5 MILES. STATIC HEAD 25 FT.
SP. G. 0·760 VISCOSITY 0·5 CENTISTOKES

1	2	3	4	5	6	7	8
SIZE OF LINE INCHES	FRICTION LOSS & STATIC HEAD FEET	B.H.P. REQD.	INSTALLED COST OF LINE 10 YR. DEP. $	INSTALLED COST OF PUMP STA. 10 YR. DEP. $	ATTENDANCE & MAINTENANCE $/YR.	RUNNING COSTS $/YR. AT 1¢/KWH	TOTAL COSTS $
6	3145	1470	17.000	8350	12.000	48.000	85,350
8	640	300	21.400	3400	10.000	9.800	44.600
10	236	110	30.000	1000	9.000	3.600	43.600
12	114	53	39.000	800	8.000	1750	49.550
16	59	28	56.000	550	7.000	920	64.470

Cost determines size. From the table, the pump horsepower and line size is fairly well defined. The cost goes up with size of pipe while the installed cost of the pump, maintenance and operating costs decrease with an increase in pipe size at another rate. A 10-inch line with suitable pump and 110-hp prime mover would be the economical choice. This fact is illustrated graphically in Figure 1.

Having established the head and horsepower requirements for 1,220 gpm, the choice of pump is straightforward. Figure 2 shows a nest of curves for one type of pump. The operating point falls on a pump using a 15½-inch diameter impeller, at 1,750 rpm, absorbing about 87 hp at 77 percent efficiency.

Multiple Station System . . .

Evaluation of optimum pipe size and number of booster stations on a long-distance pipe line is more complicated. Merely dividing the total length into

equal distances presents a wide variation in horsepower requirements for each section. Some sections will have a large static head and others a negative head due to changes in elevation. To prevent such a situation, the line must be balanced hydraulically, i.e., the line should be divided so that each section will have equal horsepower requirements.

Graphic solution. Determining the correct hydraulic points for stations mathematically is a tedious and time-consuming job. Solving the problem graphically is much simpler and has only a small margin of error. The hydraulic gradient of a 10-mile, 6-inch line is shown in Figure 3. The vertical line corresponds to the available head of the pump and the horizontal line A-B represents the length of line through which this head is dissipated by friction loss. Since the slope of the hypotenuse, termed the hydraulic gradient, represents the rate of head loss, the vertical distance between any point on the hypotenuse and the contour represents the pressure or head on the line at that point.

In the case of profile A-E a pump with a 400-foot head could move the product 2.4 miles against a static head of 300 feet with 100 feet of head dissipated in overcoming friction drop to point E. Similarly for profile A-D, 280-feet of head is used in overcoming friction losses and 120-feet to overcome static head, while at A-C there is a positive static head of 95 feet (F-C), giving a total available head of 400 + 95 or 495 feet to overcome friction. In this section the fluid can be pumped 12.5 miles.

Termed the Modular Method, the use of such a hydraulic triangle greatly facilitates the design work for long-distance lines. Negligible error is caused by the difference in horizontal map distance and the actual over-ground distance. In Figure 3, the line A-E is only 300 feet in 2.4 miles, i.e. 1 foot in 42 feet. Even in the case of a very steep gradient for Example, 1 in 4, the error is only 3 percent and allowance can be made in such cases.

Profile Required for Long Lines. To design a pipe line system 400 miles long to carry 100,000 barrels of crude oil per day, the first step is to obtain a contour map of the area. In addition, a reconnaissance of the proposed route is necessary to avoid any obstacles. An elevation profile is prepared from the contour map or from survey notes. Knowing the fluid to be pumped and the desired flow rate, the friction loss per 1,000 feet is determined for various diameter lines.

Results of friction loss calculations are tabulated in Table 2. Also included are the distance in miles that a medium-pressure pump (1,000-foot head—390 psig) and a high-pressure pump (2,000-foot head—780 psig) will transfer 100,000 barrels of crude oil per day assuming no elevation change.

Using the Hydraulic Triangle. The Modular System or, as its name implies, the "model measuring" method, is used to determine the position and number of booster stations by combining static and friction heads on hydraulic gradient triangles, the scales of which correspond to scales selected for the profile of the pipe line route.

CASE 1—Medium Head Pumps—12-inch Line

As shown in Figure 5, the hydraulic triangle is placed on the line profile with the right-angled corner coinci-

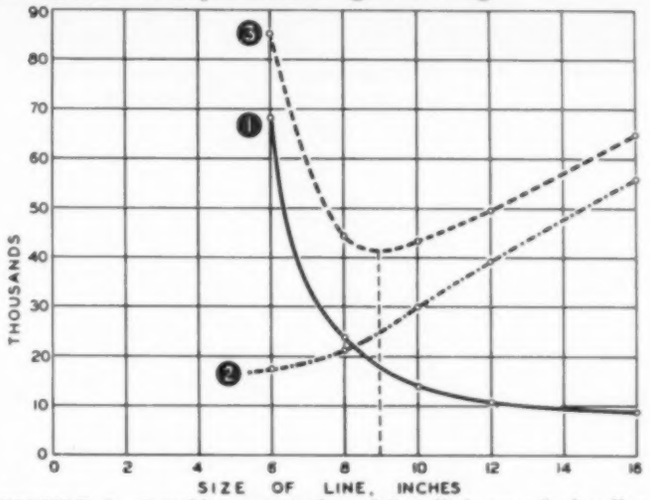

FIGURE 1—Graphic presentation of installed cost of pipe line and pump station for 5-mile gasoline line handling 25,000 barrels, operating 12 hours daily. (1) Cost of pump, prime mover, operation and maintenance. (2) Cost of line. (3) sum of curves 1 and 2.

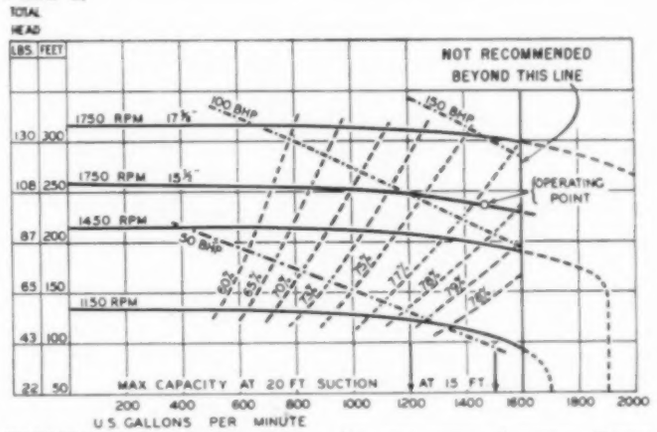

FIGURE 2—Operating curves for one type of pump. Pump using a 15½-inch diameter impeller operating at 1,750 rpm absorbing approximately 87 hp at approximately 77 percent efficiency is indicated.

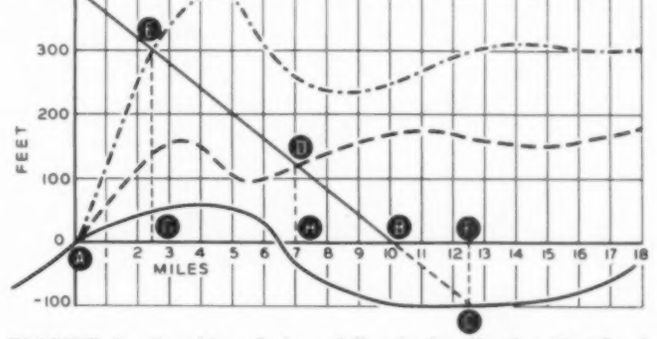

FIGURE 3—Graphic solution of line hydraulics for 10-mile, 6-inch line with 400-foot head pump. Hydraulic gradient is represented by diagonal line. Slope of diagonal at any point represents the head on the line at that point.

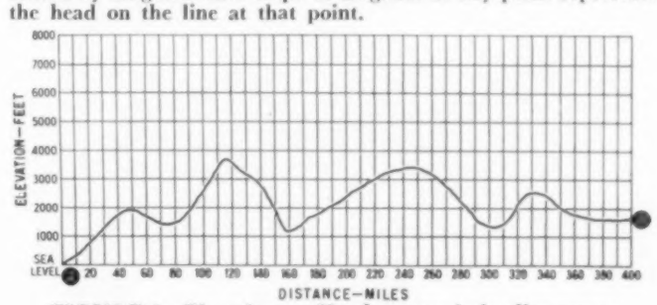

FIGURE 4—Elevation profile of proposed pipe line route.

dent with the base station *A*. Where the hypotenuse cuts the profile is the location to which 100,000 bpd can be pumped against the combined heads, indicating the position of the first booster station. Normally the base triangle is dropped slightly, about 50 feet (20 psi) to insure a positive suction at the next pump. If construction of the scales is accurate, this 20 psi should prevail at each successive pump suction. The triangle is then moved until the bottom left-hand corner is coincident with the point at which its hypotenuse in the first position cuts the profile and the point at which the hypotenuse now cuts the profile is marked, locating the second booster station. This procedure is repeated until terminal point *B* is reached. In this particular case, 47 pumping stations would be required, using 12-inch pipe and 1,000-foot head pumps.

TABLE 2

HEAD LOSS FOR 100,000 BBL/DAY OF CRUDE OIL THROUGH VARIOUS SIZE LINES
CRUDE S.G. = 0·900
VISCOSITY 10 CENTISTOKES

LINE SIZE INCHES	HEAD LOSS FT./1000 FT. OF LINE	HORIZONTAL DISTANCE IN MILES FOR	
		2000 FT. HEAD	1000 FT. HEAD
12	21·0	18·0	9·0
16	7·4	51·0	25·6
20	2·6	146·0	73·0
24	1·0	378·0	189·0
30	0·25	–	760·0

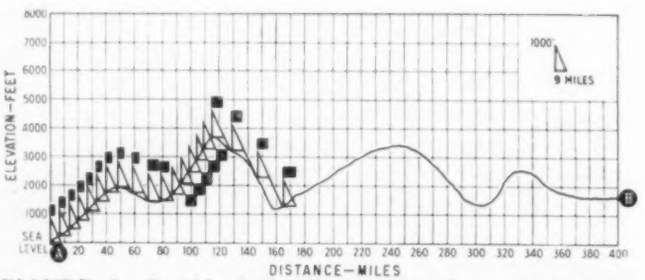

FIGURE 5—Graphic hydraulics solution for a 12-inch line handling 100,000 barrels of crude oil per day with 1,000-foot head pumps using hydraulic triangles.

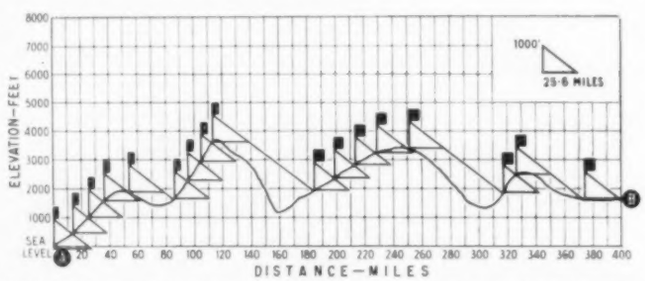

FIGURE 6—Graphic hydraulics solution for a 16-inch line handling 100,000 barrels of crude oil per day with 1,000-foot head pumps.

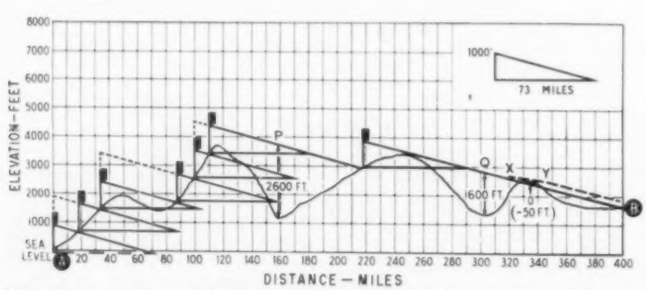

FIGURE 7—Graphic hydraulics solution for a 20-inch crude oil line handling 100,000 barrels per day with 1,000-foot pumps.

CASE 2—Larger Diameter Pipe

Proceeding in the same manner, triangles representing 16-inch pipe show that 17 pumping stations would be required (Figure 6) and with 20-inch pipe, only 7 stations are required (Figure 7).

Figure 7 indicates a head at point *P* of 2,600-feet. This is equivalent to 971 psig and would entail laying about 60 miles of heavier wall pipe, between the 140- and 200-mile points. Station 7's hydraulic gradient cuts the peak at the 330-340 mile mark to the extent of about minus 50 feet, which would cause vaporization at that point. A low head booster at the 330-mile mark, or 30 miles of 24-inch pipe from "x" to "y" would insure a positive pressure in the line under flow conditions.

CASE 3—High-Pressure Pumps

Figure 7 also illustrates the effect of using higher head pumps. Dotted hydraulic triangles indicate only three 2,000-foot head pumps would be required to pump as far as the 220-mile point, after which one 1,000-foot head pump, with the slight line size modification, will furnish the necessary capacity for the remainder of the line. Four stations would be required in this case but heavier wall pipe would be necessary.

Figure 8 shows the effect of 24-inch pipe with other practicable variations. The continuous line indicates five stations would be required with medium head pumps, however the static head due to elevation drop is greater than the friction drop in the section between Station 5 and the terminal. Horsepower requirements at Station 5 could therefore be reduced or alternatively the line size could be decreased to 20-inches from the 256 mile point below *Y* to the terminus. Because of high head (3,100 feet or 1,200 psi), heavier wall pipe would be required between the 136- and 200-mile points. Other alternatives to overcome high line pressure due to elevation changes would be to lay 16-inch pipe from Station 5 to the 180-mile point, install a 2,000-foot pump and 20-inch line from there to the 226-mile point and a 1,000-foot pump and 20-inch line to the terminal.

Larger Pumps Have More Effect. On steeply rising ground, increasing the line size, i.e. flattening the hydraulic gradient, has less effect than increasing the pump head. Between Stations 3 and 4, changing from 24- to 20-inch pipe would result in only a 6-mile difference in length due to the fact that most of the pump head is dissipated in overcoming static head. By using two 2,000-foot head pumps to the 112-mile point (as shown by the dotted line) and a lower head pump with 24- and 20-inch pipe from the 112-mile point to the terminus would require only three pump stations. However, this solution would require heavier wall and therefore more expensive pipe for part of the line.

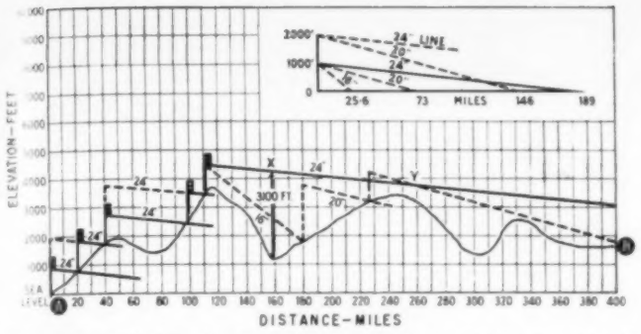

FIGURE 8 (Above)—Graphic hydraulics solution for 16, 20 and 24-inch lines handling 100,000 barrels of crude oil per day with 1,000 and 2,000-foot head pumps.

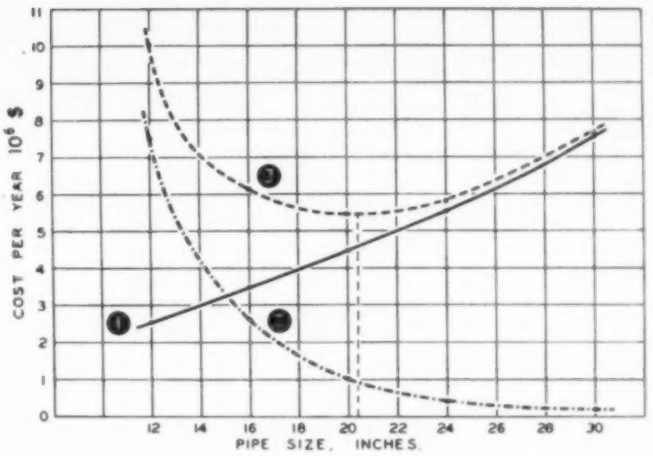

FIGURE 9 (Right)—Annual costs for 400-mile crude oil line handling 100,000 barrels per day based on 10-year depreciation of equipment and estimated maintenance and operating costs. (1) Cost of line, (2) Cost of equipment, maintenance and operation. (3) Sum of 1 and 2.

Economics Deciding Factor . . .

All of the alternatives would pump the required 100,000 bpd of crude oil 400 miles from *A* to *B*, but only a few are economic propositions. Some, like the 27-station, 12-inch line proposal are obviously uneconomic, others might not be practical from an operating standpoint, such as having different diameter pipe in a line which required regular scraping, or pump stations in inaccessible locations.

TABLE 3

INSTALLED COST OF PIPE LINE AND PUMPING STATIONS FOR 400 MILE SYSTEM

LINE SIZE INCHES	INSTALLED COST OF LINE PER MILE $	TOTAL COST OF LINE 10^6 $	NO. OF STATIONS	TOTAL H.P.	COST OF STATIONS AT $470/H.P. 10^6 $
12	63,000	25·2	45	45,000	21·20
16	87,000	34·8	16	16,000	7·53
20	112,000	44·8	6	6,000	2·82
24	139,000	55·5	2	2,000	0·94
30	194,000	75·0	1	1,000	0·47

TABLE 4

EFFECT OF PIPE SIZE ON INVESTMENT AND OPERATING COSTS

LINE SIZE INCHES	NO. OF STATIONS	INVESTMENT BASED ON 10 YEAR AMORTISATION 10^6 $		MAINTENANCE & ATTENDANCE AT $15,000/STA/YR 10^6 $	RUNNING COSTS AT 1·5¢/H.P.H. 80% OPERATING TIME 10^6 $	TOTAL COST PER YEAR 10^6 $
		PIPE LINE	PUMPING STATIONS			
12	45	2·52	2·12	0·675	4·72	10·035
16	16	3·48	0·753	0·240	1·68	6·153
20	6	4·48	0·282	0·090	0·63	5·482
24	2	5·55	0·094	0·030	0·208	5·882
30	1	7·50	0·047	0·015	0·104	7·666

To eliminate the impracticable solutions, the next step is to tabulate the investment, maintenance and running costs for all alternatives as was done on the simple example shown in Table 1. Installed costs of pipe, pumping stations and equipment are estimated and given an annual value based on agreed depreciation rates; usually 10 to 15 years for pipe lines. Also, the annual maintenance and operating costs are estimated for each case. The sum of costs for each case is plotted and the minimum annual cost found. A cost analysis on the problem reviewed covered nine variations of pipe size and pump head and resulted in a minimum annual cost for the 20-inch line with seven medium head pump stations.

Operating Costs Affect Solution. Too much cost data were involved to show clearly in tabular form, but the method of cost analysis can be demonstrated by simplifying the problem. Assuming level terrain along the 400 miles between *A* and *B*, the alternatives involve the use of 1,000-foot head pumps and five sizes of Schedule 40 pipe. Installed costs are tabulated for each alternate in Table 3.

Annual operating costs based on a 10-year depreciation of equipment and estimated maintenance are included in Table 4. The sum of all costs again shows a minimum annual cost for 20-inch pipe and the corresponding number of stations. A graphic presentation of the simplified problem is illustrated by Figure 9.

Other Factors Considered. Several simplifying assumptions were made in discussion of the problems. One is the use of only one pump at each station. Depending on the individual situation several small pumps might be used to give the total head required allowing for pump failures, or spare pumps could be installed at necessary locations.

Additional complications include variations in crude oil properties (gravity and viscosity) due either to a seasonal temperature variation or changes in crude type, addition of branch lines, and most important, allowance for future increases in pipe line capacity with the least increase in investment. These and many other factors are solved, not by graph or calculation, but by "business judgment"—another field of pipe line design.

—The End

Gas Storage Well Deliverability Boosted by Fracturing

Most underground storage fields can be stimulated by hydraulic fracturing if wells are properly selected and completed. Optimum injection and delivery rates can be achieved at a fraction of the cost of a new well.

By A. B. Waters and H. J. Ayres
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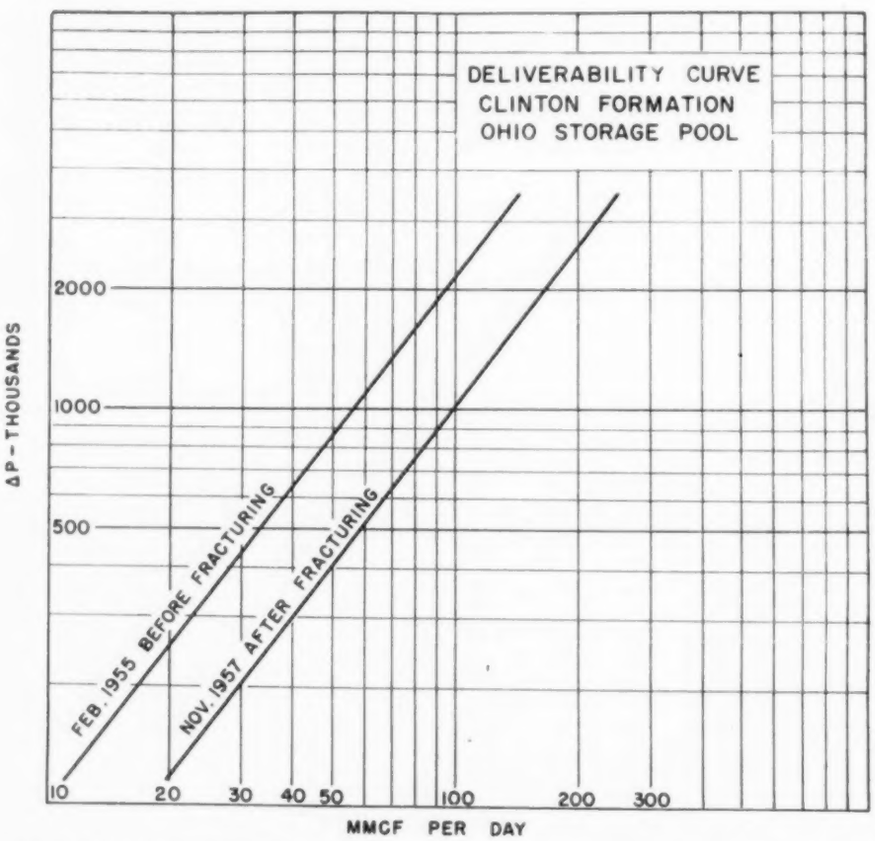
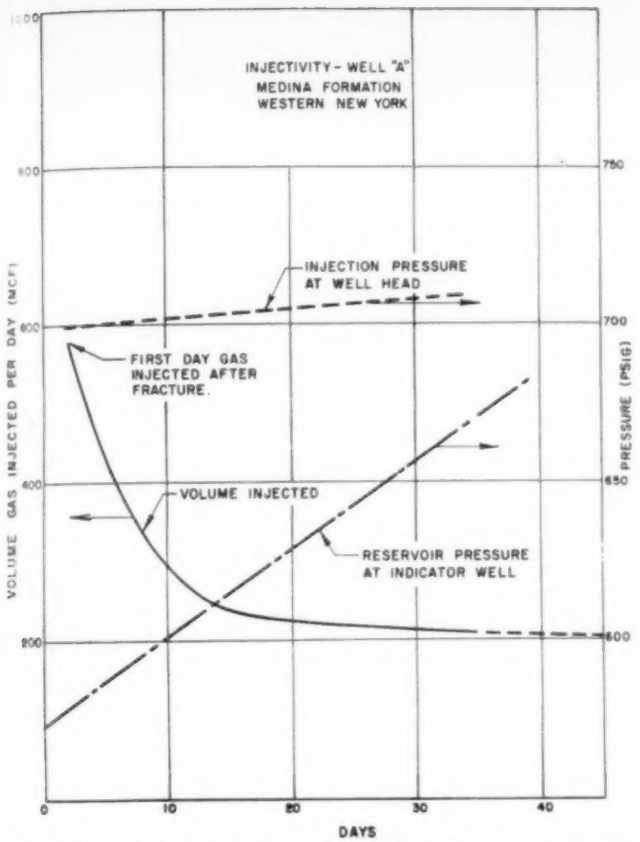


FIGURE 1—Comparison of well deliverability in Clinton formation of an Ohio pool before and after fracturing.

UNDERGROUND STORAGE of natural gas near large consumption areas has proven its economic feasibility for the big-inch cross country gas transmission lines in recent years. In many of these underground storage fields, hydraulic fracturing of existing wells has improved reservoir efficiency for a fraction of the cost of drilling new wells.

For highest efficiency the gas storage reservoir must be capable of rapidly accepting and delivering large volumes of gas at reasonable pressures. Sufficient channels, either natural or artificially created, must exist to permit free flow to and from the formation to achieve this performance. Permeability blocks near the well bore often result in high resistance to injection and withdrawal. Stimulation is especially beneficial in these. Currently, hydraulic fraturing is the stimulant which generally gives capability increases most economically.

Why Fracture? Fracturing establishes one or more avenues of high permeability from deep within the formation to the well. In reality, it increases the effective diameter of the



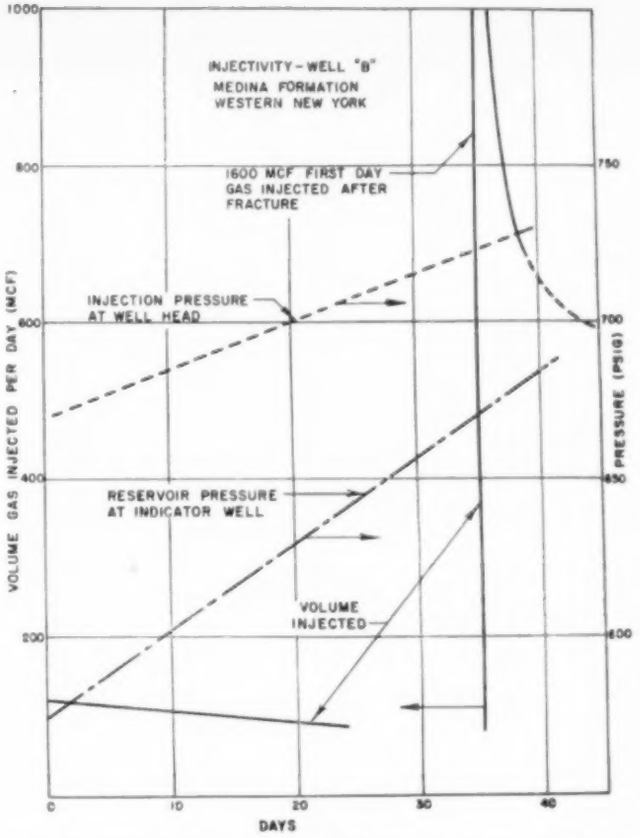


FIGURE 2—Injectivity curves for wells in Medina formation in western New York have peak values the first day after treatment. As reservoir pressure builds up the injectivity rate dropped off, but it was still at a much higher rate than before fracturing.

bore. The higher average effective permeability obtained results in greater injectivity and deliverability at a given pressure since the effect is distributed over a larger area further from the well. The pressure drop is not so great at any one point and there is less tendency for localized areas of high or low pressure during injection and withdrawal.

By application of this stimulant to a new storage project, desired capability may be obtained with fewer wells since each should have higher injectivity and deliverability. Efficiency of many existing fields which contain the full complement of wells may also be improved with fracturing. In addition, increased injectivity results in the expenditure of less compressor horsepower per unit volume of gas.

Since hydraulic fracturing often increases a well's capability several-fold at a fraction of the cost for a new well, capital investment per unit volume handled is reduced appreciably; at the same time operating expense is lowered. These factors contribute to more economic storage field operation.

Cost Data Show Fracing Payout. Cost analyses by one company indicated fracturing an existing well offered an appreciable economic advantage over drilling a new well in either of its two Ohio peak storage fields in the Clinton formation. This study was based on all of the expenditures for the new well versus cost of fracturing an old well and considered gains from each.

Fracturing fluids employed were gelled hydrocarbons of two types. Volumes varied from 2,000 to 12,000 gallons carrying one to two pounds of sand per gallon. Injection rates up to 47 barrels per minute were utilized; the average being approximately 20 barrels per minute.

Comparative deliverability tests, under similar pressure conditions in a field where 25 of 40 wells had been fractured, indicated an increase of 161 to 208 percent depending on the pressure drawdown. This increase is shown in Figure 1.

Another Ohio storage field where 24 of 42 wells had been stimulated showed a 24-hour rating increase of 2½ times after fracturing, but still using the same line pressure.

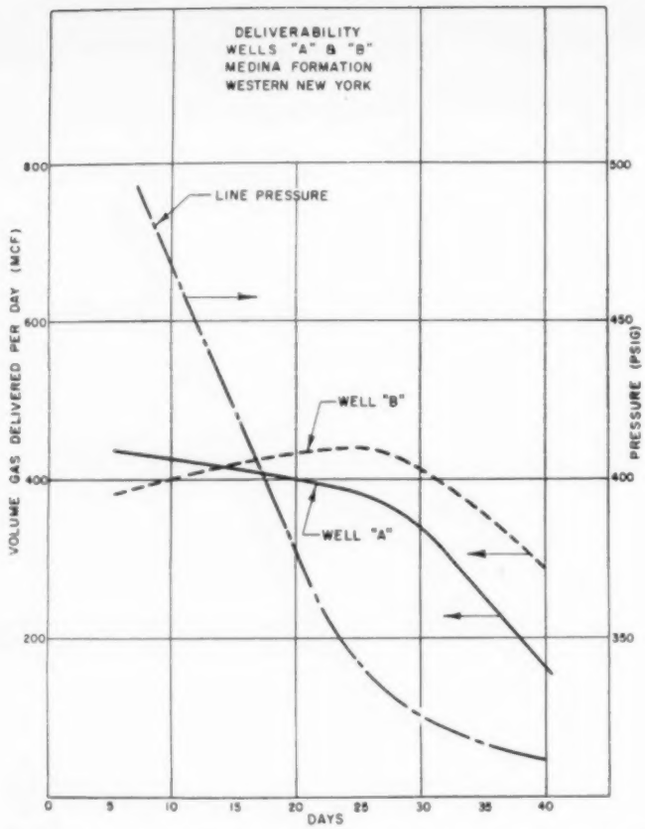
Several storage units in western New York utilize the Medina formation. These fields are used as a constant supply throughout the cold weather period, yet meet peak demand requirements.

Injectivity and deliverability of many wells have been improved several-fold by hydraulic fracturing at an average total cost of about $2,500 to $3,000; the expenditure for a new well approaches $25,000.

Figure 2 shows injectivity on two wells for a period of time following fracturing. A rapid decline in injectivity was observed immediately following treatment then leveled out to a normal slope according to pressure buildup in the reservoir. Well B appears to be an excellent example of fracturing through a permeability block near the well bore. Injectivity prior to fracturing was below field average but, after treating, higher than normal post-treatment injectivity was observed.

Formations, Wells Respond Differently. As with producing wells, different deliverabilities can be expected following stimulation; Figure 3 compares deliverability of the two New York Medina formation wells.

This formation contains a minimum of water sensitive materials and a siliceous cementing or bonding agent. The owner chose water gel as the



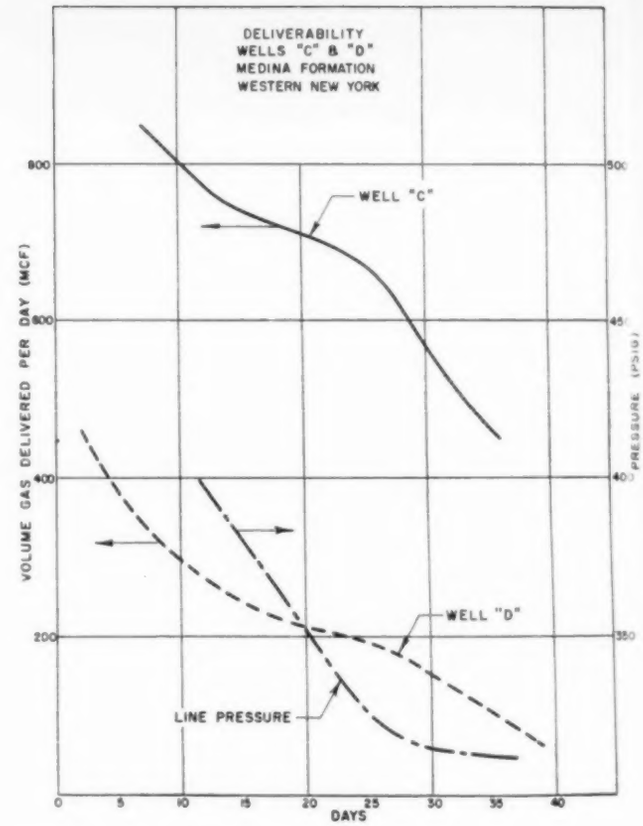


FIGURE 3—Typical deliverability curves for wells in New York Medina formation points up relationship between well volume rates and line pressure after fracturing.

most economical and safest fluid compatible with the zones.

Stimulation technique here consisted of injecting 500 gallons of water containing a surfactant followed by 4,000 to 8,000 gallons of gelled water carrying two pounds of sand per gallon at 10 to 12 barrels per minute. The surfactant expedited recovery of treating fluids. Larger volumes and higher injection rates have not shown appreciably better results in this area. Average open flow increased 6.3 times as a result of these treatments.

Michigan Well Treatment Used Fracturing-Chemical Action. In Michigan, fracturing has improved the performance of a storage reservoir being developed in the Salina formation. On the wells fractured, average deliverability against line pressure was increased 262 percent at a cost slightly more than 27 percent of drilling and completing a new well.

From core evaluations, gelled water containing a small amount of acid was selected as the fracturing fluid; it offered a dual effect—physical fracturing and chemical reaction. After drilling out cement, the open hole was cleaned with 2,000 gallons of non-emulsifying acid; this gave an approximate threefold average increase.

After adequate testing, wells were fractured with 30,000 gallons of the gelled water-acid mixture carrying three-fourths to one pound of sand per gallon.

Treatments were conducted through both 2-inch tubing and the annular space between tubing and casing. A water soluble plugging agent was introduced at five or more stages to direct the fluid to other points in an attempt to obtain additional fractures. A minimum expenditure of gas was required to expel treating liquids from the well after treatment.

These treatments increased daily gas delivery on five wells from 16,480 Mcf prior to fracturing to 43,200 Mcf subsequent to stimulation.

Mid-Continent Well Deliverability Up 216 Percent. Fracturing the Bartlesville sand in one Mid-Continent gas storage field has resulted in excellent capability increases. With equal volumes of gas in storage; and for all practical purposes equal injection rates, injection pressures were reduced approximately 18 psi. As a result of stimulation, comparison of delivery against 200 psi line pressure revealed the following benefits of fracturing:

Shut-in Pressure (psig)	Deliverability (MCFD)			Percent Increase
	Before Treatment	After Treatment	Increase	
212	3,035	9,588	6,553	215.9
295	23,898	53,167	29,269	122.5
383	46,286	89,992	43,706	94.4

At the same time absolute open flow increased 59.5 percent.

Figure 4 shows a typical plot of back pressure tests before and after treatment. Displacement of the curve to the right and steepening of the slope indicates increased deliverability; this is particularly desirable at lower formation pressures.

On an average, 15 feet of open hole was treated with 10,000 gallons water carrying 7,000 to 10,000 pounds of sand. Large diameter casing permitted injection rates of 29 to 38 barrels per minute at the low pressures of 400 to 800 psi.

Where To Fracture. There are precautions which the well owner should take before embarking upon a program of well stimulation. All well in-

formation and other factors over which he has control should be weighed carefully.

Selecting Wells. In any gas storage project, probably not all of the wells will be fractured initially. Some will not have suitable casing nor be properly cemented to withstand the applied pressures; others will perform adequately without stimulation.

Selection of those to be treated should be made very carefully. Before treating wells adjacent to the edge of a field, the well owner should consider possible damage to the natural closure of the reservoir.

Formation Considerations. Fracturing low permeability formations generally gives considerable increase, but those with permeability impedance (natural or induced) in the immediate vicinity of the well bore usually show the greatest improvement. These latter wells usually have normal capability beyond the block so that properly placed fractures will provide channels of high capacity through the block.

Figure 2 is an excellent example of fracturing through such a block. The four point or some other type drawdown test can be made to determine whether the low efficiency is due to naturally poor permeability or some other restriction.

Completion Methods. Fracturing pressure should be confined to the zone of interest to help prevent fracturing an undesirable zone such as a shale section, overlying strata, or bottom barrier of the zone. If an open hole completion is desired, casing should be set into the top of the storage interval.

Reservoirs containing more than one porous zone may be better utilized by setting casing through them and selectively perforating each porous interval. Individual zones may then be treated separately and more control may be maintained over fracture placement. Although completions such as type "A" in Figure 5 have been successfully used, types "B" and "C" are preferable.

Regardless of casing program, sufficient cementing material should be employed to protect the casing from pressure and corrosion. Before fracturing a formation containing undesirable fluids in the lower portion, it is advisable to cover the fluid producing section with a permanent type plug to help divert the fracture from that part of the hole.

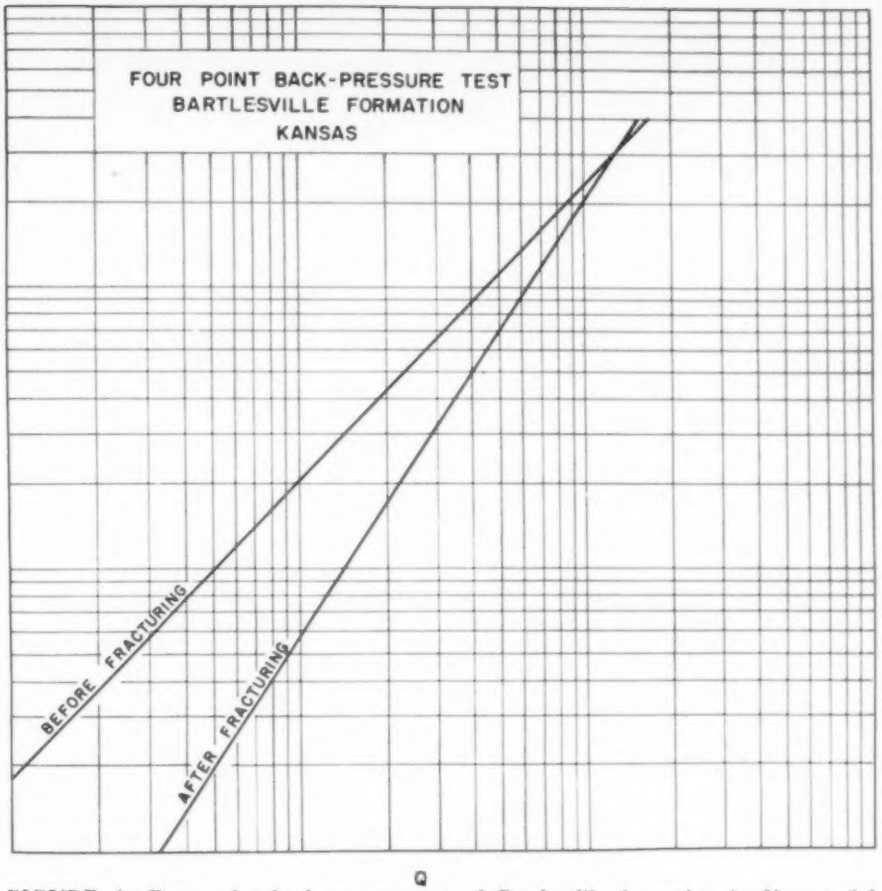


FIGURE 4—Four point back-pressure test of Bartlesville formation in Kansas field shows increased quantities of gas handled after fracturing.

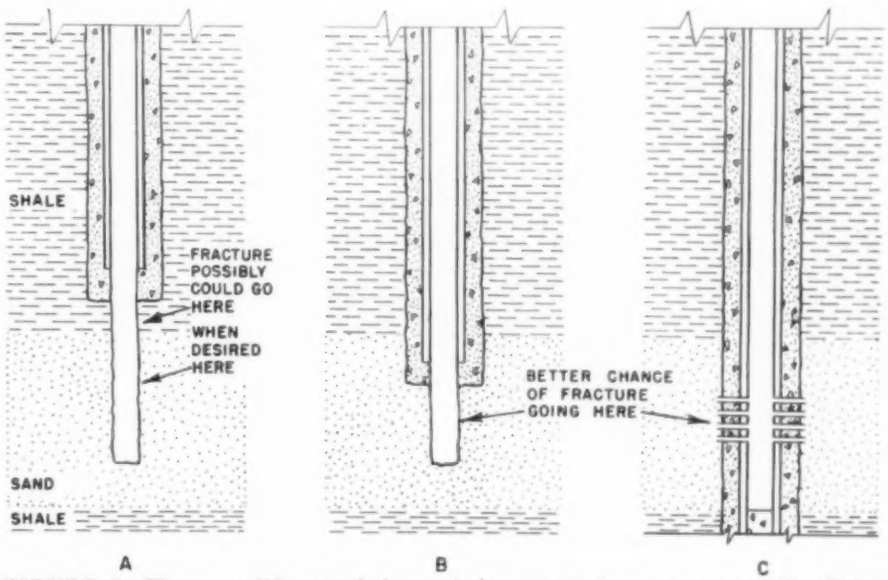


FIGURE 5—Three possible completion techniques used in gas storage wells. Either Type B or the perforated Type C would give the best chance of fracture in the desired sand formation.

Fracturing Fluid Section. Numerous fracturing fluids (oil, water, or acid-base) are available to meet the many formation and treating conditions encountered. Criteria used to select a fluid for a particular well should include:

1. Compatibility with formation and its fluids.
2. Treating conditions.
3. Safety.
4. Field experience.

To determine compatibility of a treat-

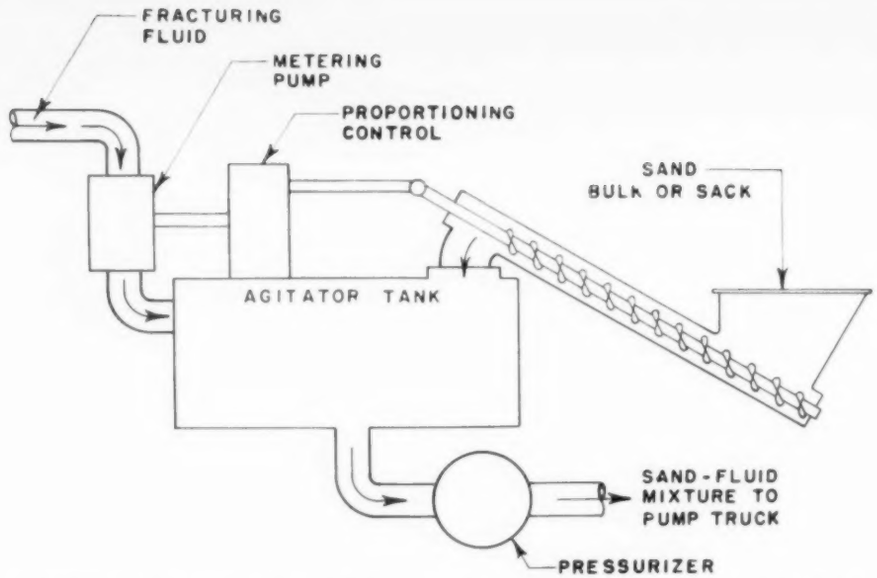


FIGURE 6—Schematic of sand-fluid proportioning equipment to be used in the hydraulic fracturing of a gas storage well. Fracturing fluid composition and blending conditions are varied to meet the specific requirements of each well, depending upon formation and method of completion.

ing fluid with a formation, it is advisable for the well owner to have a laboratory evaluation of cores for mineral content, effect of immersion in various fluids, sodium chloride content and solubility in hydrochloric acid. Special tests can determine whether the formation fluids and treating fluids are compatible or prone to emulsification.

Fluids used in treatments performed at high injection rates require less viscosity or thixotropy than low rate job. Laboratory analyses may indicate more than one fluid as being adaptable to a particular formation in which case field experience, economics, injection rate and safety become the major criteria for final selection.

Modifying Treating Fluids. Characteristics of most treating fluids may be modified to meet specific formation or treating conditions. Low fluid loss additives reduce the amount of fluid lost to the formation during creation and extension of a fracture. Greater fracture depth may be obtained with a given volume of fluid and generally less difficulty is encountered with sand placement. These agents also increase the versatility of most fluids.

Adaptability of water for treating certain formations can be improved by addition of anti-clay swelling materials such as sodium chloride, calcium chloride or hydrochloric acid. Incorporation of surfactants aids in preventing emulsions and often expedites recovery of fracturing fluid following a treatment—an important consideration for storage wells due to cost of gas utilized in expelling it.

Propping Agents. Since the introduction of fracturing, there has been considerable discussion on the necessity of a propping agent; however, laboratory and field experience generally confirm that higher sustained capabilities are obtained when it is employed.

For maximum flow capacity as large a propping agent as is practical for the particular well condition should be injected; a sand with a particle size gradation from 20 to 40 U. S. Standard mesh is most often used. Some formations will not readily accept large-grain sand throughout the treatment.

Very beneficial results may be obtained by concluding a treatment with large-grain sand or a higher concentration of regular sand. When initiating a fracturing program for a reservoir, generally the treatment is started at a low sand concentration (¼ to ½ pound per gallon of fluid) and gradually raised until the desired ratio has been reached. This sand tapering technique has become a standard practice when treating many formations. In order to provide these variable sand-fluid ratios accurately, devices such as shown in the schematic diagram Figure 6 were designed for a wide range of injection rates.

Various Fracturing Technique. More than one fracture may be highly desirable when long sections of formation are exposed, where the reservoir is composed of several zones, or if the storage interval is highly laminated. Often more than one fracture is made in a conventional treatment, but procedures are available which enhance the possibility of obtaining multiple fractures.

In open hole or perforated completion, special graded soluble granular materials or viscous gels can be used to temporarily seal previous fractures and divert fluid flow and pressure to another portion of the well bore.

Another technique for cased and perforated completions utilizes small rubber or rubber-covered nylon spheres metered into the injection stream to seal perforations taking fluid. Pressure is then exerted against a different portion of the formation through other perforations. As pressure is released, the balls fall from the holes and permit reverse flow.

Efficiency of wells producing scale-forming waters frequently can be improved by incorporating special phosphates in the propping agent utilized in fracturing treatments. By retarding precipitation or crystallization of these scales for several months, more sustained capabilities are usually obtained.

Special acid base clean-out agents and surfactants can be very beneficial when used preceding or in conjunction with a fracture treatment. Acid base agents assist in removing drilling muds and formation fines that have been forced into the formation permeability during drilling or remedial work. It is recommended that these be injected and removed prior to fracturing. This aids in preventing the plugging materials from being forced further into the formation during a fracture treatment.

Surfactants either break emulsions or help prevent emulsification by reducing surface and interfacial tensions between hydrocarbons and water that are present in the formation or used in the treatment. These fluids can then migrate more easily to the well bore.

Planning Your Fracing Program. After selecting wells to be fractured, determining proper casing and cementing program, and selecting desired fluid, the treating procedure should be established. In order to ob-

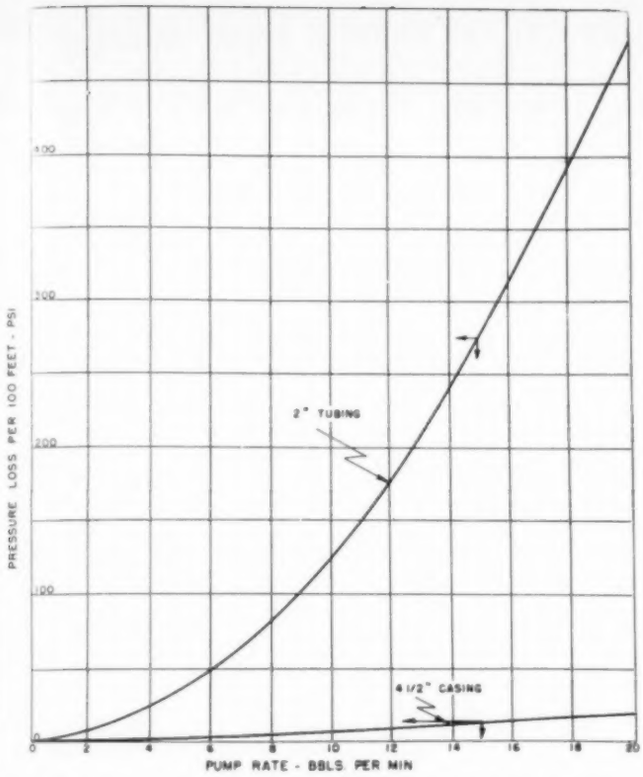


FIGURE 7—Pressure loss curve for fracturing fluid at various pumping rates illustrates that hydraulic horsepower demands of smaller tubing might make a fracturing job uneconomical. With the larger 4½-inch casing, pressure drop advantages would make it the most economical choice.

About the Authors

A. B. Waters, staff engineer for fracturing with Halliburton Oil Well Cementing Company, has a wealth of experience in work with drilling fluids, cements, and hydraulic fracturing. He joined Halliburton in the company's chemical research laboratory in 1946. After graduation from Murray State College in 1941, Waters was employed as a physicist by E. I. duPont de Nemours, and as a chemical engineer trainee by Joseph E. Seagrams prior to entry into military service in 1943. He is an active member of the Society of Petroleum Engineers of the AIME and other technical and engineering associations.

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tain maximum fracturing efficiency, considerable planning should go into formulating this procedure.

Many gas producing strata yield higher sustained deliverability when fractured at high injection rates than when low rates are employed. Probably one fracture cannot accept all fluid being injected at high rates; therefore, other crevices may be initiated resulting in a series of fractures being created. Greater productivity is obtained.

Some formations, however, appear to be little affected by high rates. Presumably there is a fluid volume and injection rate for each formation above which results are not commensurate with cost. Below this optimum treatment maximum efficiency may not be realized. Most of these optimum volumes and rates are relatively high.

Tubular equipment should be matched to the anticipated injection rate for the fracturing treatment so a maximum amount of the available hydraulic horsepower can be applied to the formation. When tubing is too small, considerable horsepower is expended as friction. Figure 7 is a graphic representation of calculated friction loss which may be anticipated when pumping water through 2-inch tubing or 4½-inch casing.

Consider, for example, a treatment employing water when a pumping rate of 15 barrels per minute is desired on a 2,000-foot well. Figure 7 indicates that when pumping through 100 feet of 2-inch tubing, a pressure loss of approximately 270 psi can be expected at 15 barrels per minute while 4½-inch casing offers about 10 psi loss to friction per 100 feet at the same rate. The hydraulic horsepower formula

$$\text{Hydraulic hp} = \frac{\text{gpm per minute} \times \text{pressure drop (psi)}}{1714}$$

may be used to determine horsepower lost to friction. Substitutions in this formula reveal that approximately 2,000 hydraulic horsepower would be lost to friction if 2-inch tubing were employed on the proposed treatment; but only about 75 hydraulic horsepower would be lost to friction through 4½-inch casing. This would be in addition to horsepower required to fracture the formation. Such a treatment could be performed through 4½-inch casing with a low expenditure of horsepower on friction; it would be economically impractical through two inch tubing since pumping charges are partly based on horsepower furnished.

If it is undesirable to remove tubing prior to a fracture treatment, the fluid may be pumped through both the tubing and annular space between tubing and casing. Annulus alone on larger size casing may be adequate to minimize friction. Before performing a casing or annulus type treatment, the well owner should ascertain whether the tubular equipment will withstand the anticipated pressures.

ACKNOWLEDGMENT

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Eliminating Explosions in Starting Air Lines

Survey of 53 station operators sheds light on many of the causes and best control measures. Thorough chemical cleaning of air lines and use of fire resistant lubricants are two effective solutions.

By Robert S. Ridgway
Standard Oil of California, Whittier, Calif.

EVER SINCE the practice of starting large internal combustion engines began by rolling them with compressed air admitted directly to the power cylinders, industry has had to face problems caused by explosions in the compressed air lines. Fortunately, these explosions are very infrequent. But their violence is usually so great that they are much to be feared when they do occur, as they are a grave hazard to personal safety and equipment.

The natural gasoline and pipe line industry, operating several million horsepower of such engines, has been greatly concerned with such explosions for many years, and numerous studies have been made. The NGAA has made two surveys within the last decade. Recent experimental work has thrown some very strong light on the probable mechanism of these accidents. Some relatively new products have been made available which could lead to the end of such accidents. By reviewing the operating experiences and research work—the author believes—we now have sufficient evidence at hand to fully explain these accidents.

NGAA Survey. In the 1957 survey of the NGAA, 53 companies were questioned. Twenty had experienced one or more starting air line explosions. All used the same general types of air compressors. No correlation between those having had accidents and those having none could be found between the alternates of any of the following practices: Air suction from inside or outside of the building; use of an oil bath air filter; connections to the engines made to the top or bottom of the air headers; frequency of overhaul of the air compressors; schedule of blowing down lines or tanks; use of aftercoolers for the air stream; requiring the air to flow through the air storage tank instead of having it float on the line through a tee.

Of the 20 having experienced explosions, 11 have used bursting discs on the system. Nine have stated that this equipment did not always prevent the air line from rupturing; one felt that it did, and one was not sure that there would have been a pipe line failure if the rupture disc had not been used. One reported pipe line rupture without any bursting of the disc. So from all of the above mentioned practices, many of them good, there was no helpful clue which would lead to the solution of the problem.

One pair of questions, however, brings forth answers which provides a rather strong agreement. Four operators have lubricated their compressors with a mixture of soap and water, and all four report no air line explosion occurring while the soap solution was being used. One operator, who is one of the country's largest, has been using this type of lubrication for 30 years, hence, his record is quite impressive. Another significant question asks if air line explosions have always occurred while starting engines. In this case 18 answered "yes," one said "no," and one said "not always."

Returning to the subject of soap

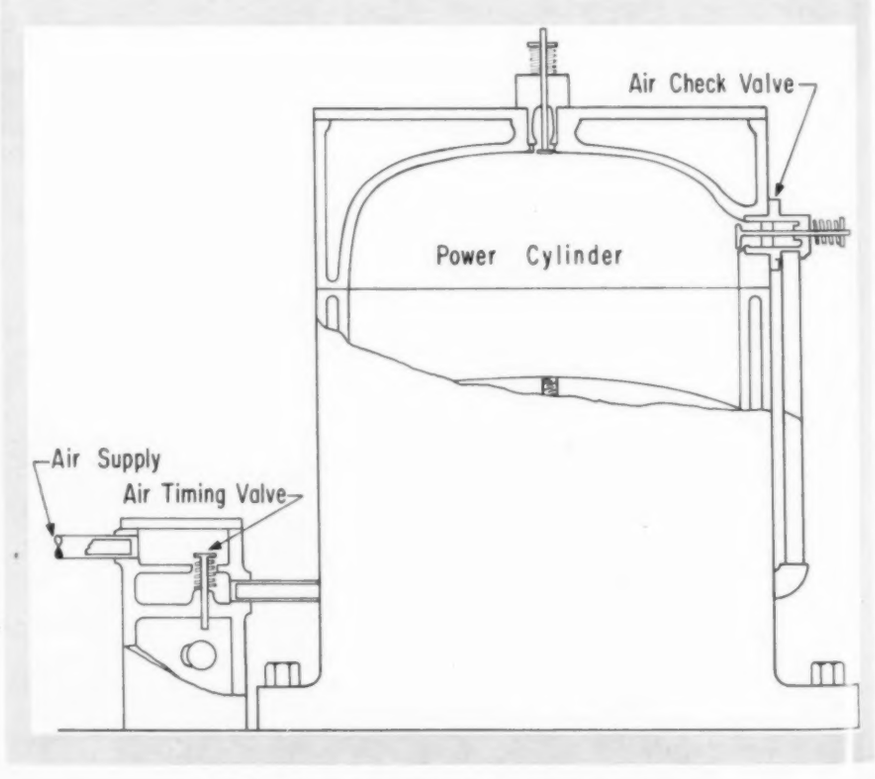

FIGURE 1—Conventional air starting system.

lubrication, one is entitled to ask why, if such a lubricant has done a 100 percent job, it is not used universally? The answer to that one is twofold. Soap is not suitable for crankcase lubrication; hence, to use this material, all of the common vertical or vee type splash lubricated compressors must be replaced by equipment, probably double acting, where the cylinders are force fed from a lubricator. This would normally be a major expense item. Secondly, not all users are satisfied with the performance of the soap solution; and some have deserted it, reporting that the soap was too troublesome in the valves and in the lines.

French Research. In July, 1952, R. Loison presented to the Seventh International Conference of Directors of Safety in Mines Research, a paper entitled "The Mechanism of Explosions in Compressed Air Pipe Ranges."[1] It so closely describes the phenomena encountered in air starting systems as to be of inestimable value to those concerned with this problem.

Thresholds. Loison made a number of experiments. The first group dealt with a mass of material, saturated with lubricating oil, which was gradually heated and over which a current of heated oxygen was passed at atmospheric pressure. When the temperature exceeded a critical value, an reaction occured; the oil vaporized and the vapors ignited spontaneously. When the mass of material holding the oil was rust, the critical temperature for spontaneous ignition was observed to be 320° F. The gas stream in this case was oxygen. Loison calculates from the partial pressure of oxygen in the air that similar results would result from the substitution of air at 70 psi. This was confirmed by passing an air stream over deposits collected from one of their compressors. The threshold of oxidation was found to be at 310° F. at a pressure of 100 pounds. This process of the exo-thermal reaction of oxygen on oil and carbon has been the subject of other papers and is well covered by the U. S. Bureau of Mines in its report R. I. 4465 published in June 1949.[2]

Loison's next experiment consisted of igniting an explosive gas-air mixture in a short pipe, separated by a thin membrane from various longer lengths of pipe containing air. The air pipe was either clean, or the walls were smeared with a thin coating of lubricating oil, or the oil was placed in long trays and laid along the bottom of the pipe. In all cases the pipe was 10 inches, with ¼-inch wall thickness. The combustion end was 13 feet long. The test ends varied in length from 115 feet to 311 feet with closed ends. The separating membrane was calculated to rupture at 85 psi and was prevented from doing so during the charging period by pumping up both ends of the pipe simultaneously. Initial pressures of 100 psi were used in all tests. In tests 1 and 2 the mixture in the combustion chamber consisted of methane and air. In the balance of the tests, slightly more oxygen was used to make the explosion still more violent, the chemical composition being 25 percent O_2, 12.5 percent CH_4 and 62.5 percent N_2.

The results of these 11 tests are tabulated in Table 1. Note that in the three where the pipe had no deposit, there was no ignition. In the remaining 8 tests, 2 showed burning without mechanical effects, and in 6, the explosions were violent and the pipe was ruptured, usually at several points.

TABLE 1

Test No.	Nature of Deposit	Length (Feet)	Result
	No deposit	311	No ignition.
	Oil and lamp black	311	Deposit burned over a length of 13 feet. No mechanical effect.
	Oil and lamp black	311	Explosion throughout the pipe. Violent mechanical effects. Pipe ruptured at several points.
	No deposit	115	No ignition.
	No deposit	115	No ignition.
	30 grams of oil/meter	230	Combustion of the oil over a length of 33 feet. No mechanical effect.
	30 grams of oil/meter	230	Combustion of the oil over a length of 50 feet. One fracture in pipe close to combustion chamber.
	60 grams of oil/meter	197	Explosion throughout the pipe. Violent effects. Pipe ruptured at several points.
	60 grams of oil/meter	164	Combustion of oil over a length of 50 feet. One fracture, close to combustion chamber.
	180 grams of oil/meter	164	Explosion throughout pipe. Very violent effects. Pipe ruptured at several points.
	180 grams of oil/meter	148	Explosion throughout pipe. Very violent effects. Pipe ruptured at several points.

Speed. From the observations of Loison, also of Elting Henderson in his paper to the PCGA in 1941 entitled "Combustible Gas Mixtures in Pipe Lines"[3] and from the work of other authors, the speed of pressure waves in pipe lines can reach several times the speed of sound. Loison measured velocities up to 4,000 feet per second; and Henderson measured them as high as 5,300 feet per second, or almost Mach 5. Where the initial explosion is sufficiently severe to initiate the shock wave near or above the speed of sound, the temperature within the shock front can be sufficient to vaporize and inflame the oil deposit in the pipe, causing combustion. The initial temperature of the air will, of course, have a bearing on this phenomenon. The combustion will, in turn, serve to propagate the shock wave which at higher speeds will attain higher temperatures and cause detonation within the pipe.

Loison calculated a shock wave temperature in the order of 870° F. in a wave front traveling at 3,300 feet per second. Actually, he observed that the speed of the shock wave when initiated by the ignition of the combustible charge was in the order of 1,300 feet per second. From this initial velocity his measurements showed the shock front accelerating to 4,000 feet per second. When detonation ruptures the pipe, the pressure wave appears to momentarily slow to the speed of sound; but the expansion connected with the rupture and possibly other phenomena accelerates the wave front again to several Mach numbers. The rupture pattern is thus repeated. It should be noted in passing that rupture does not terminate the explosion; but instead, appears to intensify it and make it repeat.

The famous Mid-Continent pipe line explosion of 1939 serves to illustrate this fact. In this explosion some 32 miles of 10-inch empty oil line was ripped apart in ruptures at various intervals when a pig was being forced through by compressed air. Henderson found that the pipe line explosions could be propagated re-

gardless of whether or not the far end of the pipe was open or closed. This was probably due to the inertia of the gas in conjunction with the speed of the mechanism. When no detonation occurs (merely combustion within the pipe) or when a second detonation does not occur following a rupture, the accelerated shock wave appears to slow down to around the speed of sound.[1]

While discussing the phenomena of such waves, it should be of value to quote an observation of Loison, who says "It is not necessary to imagine the flame front as being close to the pressure wave front. The successive rise in pressure as a result of the inflammation of new portions of combustible matter are, in effect, capable of maintaining a shock wave even if this is a certain distance in front."

Pressure. It has further been calculated that with a condition of detonation, terminal pressures in the order of 100 times the initial pressure may be expected. Loison did not measure final pressure, but with some assumptions as to the kind of pipe used, we calculate his bursting pressures to be around 2,400 psi. Henderson,[2] however, did measure terminal pressures as high as 9,000 psi, thus proving the factor of 100 for the case involving detonation. Pressures resulting from simple combustion of hydrocarbon-air mixtures can only be expected to reach a maximum pressure of 2 to 6 times the initial pressure.

Application. The application of the foregoing research work and observations to the phenomena of explosions in air starting lines is not difficult. We need only to determine the cause of the initial explosion within the system which will promote the shock wave. We then have our puzzle assembled, for we can depend upon the air compressor to supply the coating of lube oil to the pipe walls. It is our opinion, shared by many others, that a stuck or leaking air check valve permits the engine being started to pack the section of line between the check and the air timing valve (Figure 1) with explosive mixture. When this is fired from the power cylinder, the resulting pressure wave forces itself upstream through the timing valve and into the main air line. Thus, the whole starting system becomes parallel to that used in the experiments of Loison. When the circumstance of a malfunctioning check valve is coupled with a fuel-air mixture in the combustible range and good flame propagation in the power cylinder, the proper set-up is laid for explosions in the pipe system similar to those shown in Loison's experiments.

Our observations of air line explosions which have occurred while engines were being started coincide with the experiments of Loison in many ways. In the majority of such accidents where we have seen the results shortly afterward the pipe has been ruptured at several places. Frequently the line between such bursts would contain a valve or fitting which might have been expected to have ruptured at a fraction of the bursting pressure of the pipe. Yet, these did not fail because the detonation wave had not occurred at that particular spot. We once saw a 125-pound brass check valve on an air line adjacent to the power cylinder being started which was undamaged. A series 30 plug cock in the starting line against the building wall was shattered. The shock wave had apparently not gained sufficient speed to cause detonation until it had traveled some distance from the engine. Pressure from combustion alone was not sufficient to rupture the check.

There appear to be a few instances of air line explosions and fires which occurred either when an engine was not being started, or before the ignition was turned on. There are many instances of fires in air lines (not usually air starting lines), where engine starting was not involved; nor did rupture of the pipe occur. Of the former we can say that it does not seem too improbable to conceive of a chain of circumstances involving a "hot" air line due to operating an overheated air compressor too long, and carbon and rust particles saturated with oil in the line, such that the flow of starting air was sufficient to cause the exothermic reactions of the oil or carbon to result in a flame. One operator reports a fire in an air starting line which, when observed, was bled down until the line cooled off. When the air pressure was returned to the line, the fire continued. This occurrence is not uncommon in continuous duty compressed air systems. Fire, once started, continues to vaporize the oil to its ignition point.

Users of air at high pressure must be careful not to introduce a shock wave into a high pressure line by sudden opening of a plug cock. The Walter Kidde Company has done some research work along these lines and has published a report[4] in which they show that sudden admission of air at pressures above 1,300 psi caused combustion in an aluminum tube 1-inch in diameter by 10 inches long when the tubing walls were covered with a film of oil. Not long ago a local aircraft concern was charging small containers from a large storage tank of air at approximately 7,000 psi pressure. The operators were somewhat disturbed one day when, upon opening the charging cock, the main supply tank grew suddenly hot and shed its coat of paint. In both cases it is likely that the sudden acceleration of the high pressure air had set up a shock wave which had, in time, caused the combustion. In one study, we have come across a few instances where operators have been insistent that the explosion occurred at the moment the starting air cock was opened, or that the engine was being rolled with air, with the ignition, or the fuel, or both being shut off at the time of occurrence. This raises the speculation as to whether the opening of either the air cock, or the timing valve operated by the engine cam could, under an ideal set of circumstances, initiate a pressure wave which would start the mechanism described previously and cause the explosion.

Fire Resistant Lubricants. After a review of the foregoing research tests, it is little wonder that no user of soap lubricant has ever experienced an explosion in his starting air line. The common factor in all of the mechanisms appears to be the lubricating oil. Fortunately there are several materials now obtainable which are claimed to be fire-resistant, and which will lubricate. To date we know of no explosions where such materials are used, provided that the lube oil is cleaned from the system and kept out. To my knowledge these materials have been in such service less than three years; hence, we must not take this statement as conclusive proof of effectiveness.

We recently had an interesting air line explosion where a fire resistant synthetic was being used. One pipe rupture only occurred, rather close to the engine. A rupture disc a short distance away failed. The balance of

the line stayed in good shape. Close examination afterward showed that lube oil was collecting in the cam case and running down the stem of the inverted air starting valve, and thus entering the air line during the period of normal engine operation. The engine air check valve stuck during the start; hence, this was a perfect "set-up" for an air explosion. Our Mid-Continent operator, who has used soap for 30 years, tells of a similar experience, where lube oil entered the air system in a like manner and caused an explosion.

Our accident provoked two interesting observations. The first was that, although we did not dismantle the balance of the line to inspect, it did not appear that combustion occurred very far beyond the location of the engine being started. There were no series of ruptures throughout the rather extensive air system, which might be expected under operation with lube oil. From this point of view, then, the fire resistant lubricant looked promising. The second observation was that a 300-pound rupture disc did not protect a 1½-inch pipe nipple against bursting. A similar nipple from the same line was subjected to a hydrostatic pressure of 8,300 psi (the limit of our test stand) and it did not fail. If a 300-pound rupture disc will not protect 8,300 psi plus pipe, then (1) the internal phenomena could not in any sense be called "controlled combustion," nor (2) can we look to rupture discs to protect us from these accidents.

We would warn against using these fire resistant lubricants without making two thorough checks: First, thoroughly clean the oil, carbon, scale and rust from the pipe lines, else a false feeling of security is likely to exist when actually the lube oil impregnated rust, scale and carbon within the pipe wall can lie for years waiting for just the right set of circumstances to "set it off." In most of our plants we circulated a hot detergent throughout the air system until it became clean.

One of the large Mid-Continent gas pipe line operators recently switched his starting air compressors to a fire-resistant lubricant, and engaged the services of a chemical contractor to clean the systems in all of his stations. The oil, carbon and other organics were first removed with a strong caustic soda solution, followed by a flush with water and an air purge. The lines were then filled with inhibited hydrochloric acid of 20 to 30 percent strength, to remove all rust and inorganics. Water was again used to remove all the chemicals. This was a big job and it required about 30 hours per station, but when it was completed the operator had no concern over the possibility of explosions caused from the residual material within the pipe lines.

Secondly, all possibility of lube oil entering the air system must be eliminated. Inspection of various makes and models of large engines reveals that some of them permit crankcase lubricant to flow into the air distributing mechanism; and one provides an oil connection into this device to lubricate the distributing disc. Obviously the lubricant at all such points must be fire resistant, and various and sometimes ingenious methods must be employed to prevent the crankcase lubricant from entering the air system and nullifying the effect of the fire-resistant lubricant.

Combustion Pressure. Although we may be able to remove from the pipe line the material which makes detonation possible, it may not be so easy to eliminate the mechanism which sets it off. It is like saying that we can eliminate the dynamite, but not the fuse. By the fuse, we mean the mechanism of the malfunctioning check valve which permits explosive mixture to enter the adjacent air piping, and, when ignited, cause the initial pressure wave. If this combustion pressure within this pipe can be hazardous, then we must be concerned about it. It is unlikely to expect pressures within the piping adjacent to the power cylinder in the event of a faulty check valve to be materially different from those within the power cylinder. With high compression engines we would expect such pressures to be in the order of 600 psi under conditions of perfect mixture strength. For the pipe there will be no problem of containment of such an instantaneous pressure; but for valves and checks, it will be advisable to install fittings capable of withstanding such pressures. Without the material to provide the energy to propagate the shock wave, it should become harmless rather rapidly, although we are not prepared to say just how great a distance this may be. However, it does not become a major item to use Series 30 valves and fittings on air lines. More frequent servicing of the engine check valves, or the addition of a second check adjacent to the first one, or both, should reduce the incidence of packing explosive mixture into the air line.

In the author's opinion, at long last the mechanism of the deadly and treacherous starting air line explosions is understood; and there is material available which will allow us to be in control of the situation.

Original presentation was before the CNGA, April 3, 1958, Downey, Calif.

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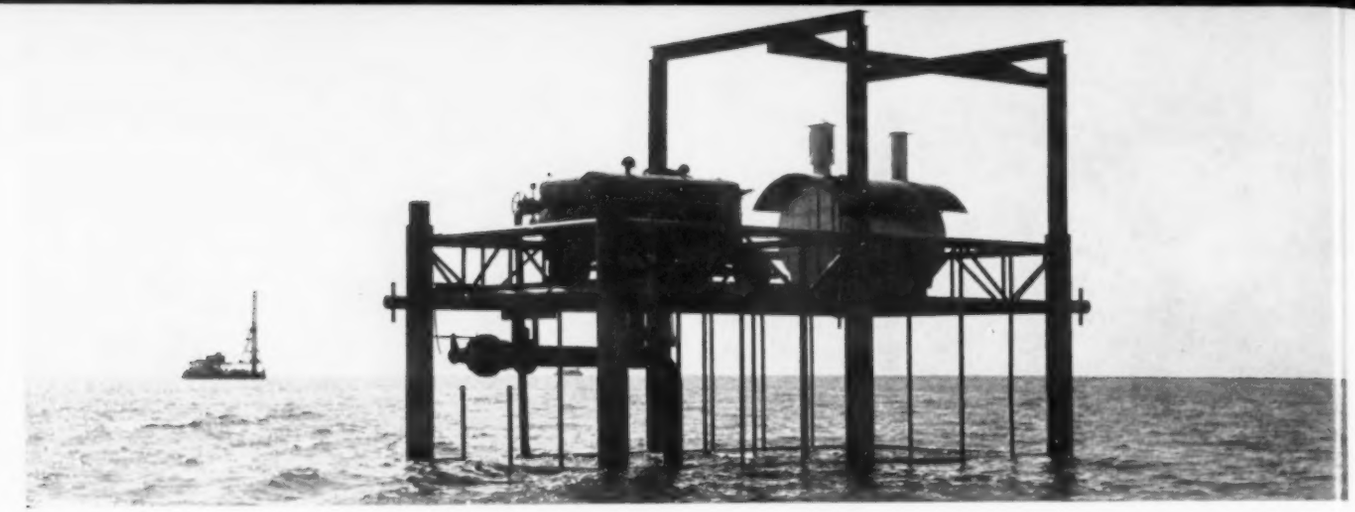
About the Author

Robert S. Ridgway has been working principally with internal combustion engines, compressors, pumps and their related equipment since receiving his B.S. degree in mechanical engineering from the California Institute of Technology in 1924. He has worked with the Natural Gasoline Department of Western Operations, Standard Oil Co. of Calif., since 1925 as a mechanical engineer. Since 1953 that department has been part of the Producing department and Ridgway has become senior staff mechanical engineer. In 1957 he was given the status of professional engineer by his company in recognition of his work. Other articles by Ridgway have been published in industry technical publications.



Diesel generator unit furnishes power for cathodic protection of offshore gathering system in the Safaniya field in the Persian Gulf. Units are placed on tie-in platform where 6-inch flow lines from the wells join the 16-inch trunk line to shore.

Aramco Protects Middle East Pipe Lines

Pipe line corrosion is a problem even in the desert. Rectifiers, magnesium anodes, diesel generators, welding machines and one windmill protect desert and offshore systems.

By Edward G. Peattie
Arabian American Oil Company, Dhahran, Saudi Arabia

ALMOST EVERY form of cathodic protection device is now being used by Arabian American Oil Company to safeguard its installations in Saudi Arabia. Rectifiers, magnesium anodes, two types of diesel generators, both electric and gasoline welders, and even a lone windmill are in operation on Aramco's system.

Corrosion forces are at work in Saudi Arabia as elsewhere. No greater fallacy ever existed than the belief that because the desert climate is dry, no corrosion would take place. Although certain rocky portions of the desert have soil resistivities as high as 800,000 ohm-centimeters, there are also coastal salt flats and interior depressions called sabkhas where highly saline waters are at or near the surface and where the resistivity may be 5 ohm-centimeters.

Coating Alone Not Enough. Even though all the buried pipe is covered with asphalt coating and wrapping, cathodic protection is necessary. Once Aramco had constructed its initial pipe line system, it soon became evident that more than coating was necessary to prevent the leaks which began to develop.

From Haradh, the southernmost area of the Ghawar field, to Safaniya, which is close to the border of the Saudi Arabian-Kuwait Neutral Zone, the distance is about 270 miles, mostly rock and sand, but occasionally varied with oases such as Qatif and Hofuf. Throughout this section, Aramco has 913 miles of oil pipe lines and of this total, 736 miles or 80 percent are buried and require cathodic protection. They vary in length from the 4-mile Uthmaniyah (UT-1) gathering line to the 270-mile 30—31-inch Qatif-Qaisumah (Q-Q) trunk, leading to the facilities of the Trans-Arabian Pipe Line Company (Tapline) and thence to the Mediterranean terminal at Sidon, Lebanon. More than 99 percent of these 736 miles of pipe line are now under what is considered to be adequate cathodic protection.

Rectifiers First Choice. The primary choice for providing direct current for cathodic protection is to use rectifiers whenever possible. A minimum amount of maintenance is required, and as long as an electrical power source is available, they are most likely to provide continuous protection. Both American and European manufacturers have supplied rectifiers and, in general, have given good service. Exceptions have been where the cooling systems of the rectifiers were inadequately designed. High ambient air temperatures in Saudi Arabia during the summer (shade temperatures are as much as 120° F. at times) make it necessary to allow for air circulation and for cooling by radiation.

Of the 44 rectifiers now in use in Saudi Arabia, 24 are designed for land cathodic protection and are usually rated at 40 volts and 100 amperes. Offshore rectifiers (used for piers and offshore flow lines) are normally rated at 25 volts and 250 amperes. Most of these rectifiers are concentrated in Ras Tanura where six protect the North pier and eight protect the South pier. The land rectifiers are located, in most cases, at the terminal ends of pipe lines where electrical current is available.

Available Power Limited. It has been found very difficult to try to protect with any degree of certainty an entire pipe line longer than 20 miles by rectifiers alone when they are arranged in this manner. For this rea-

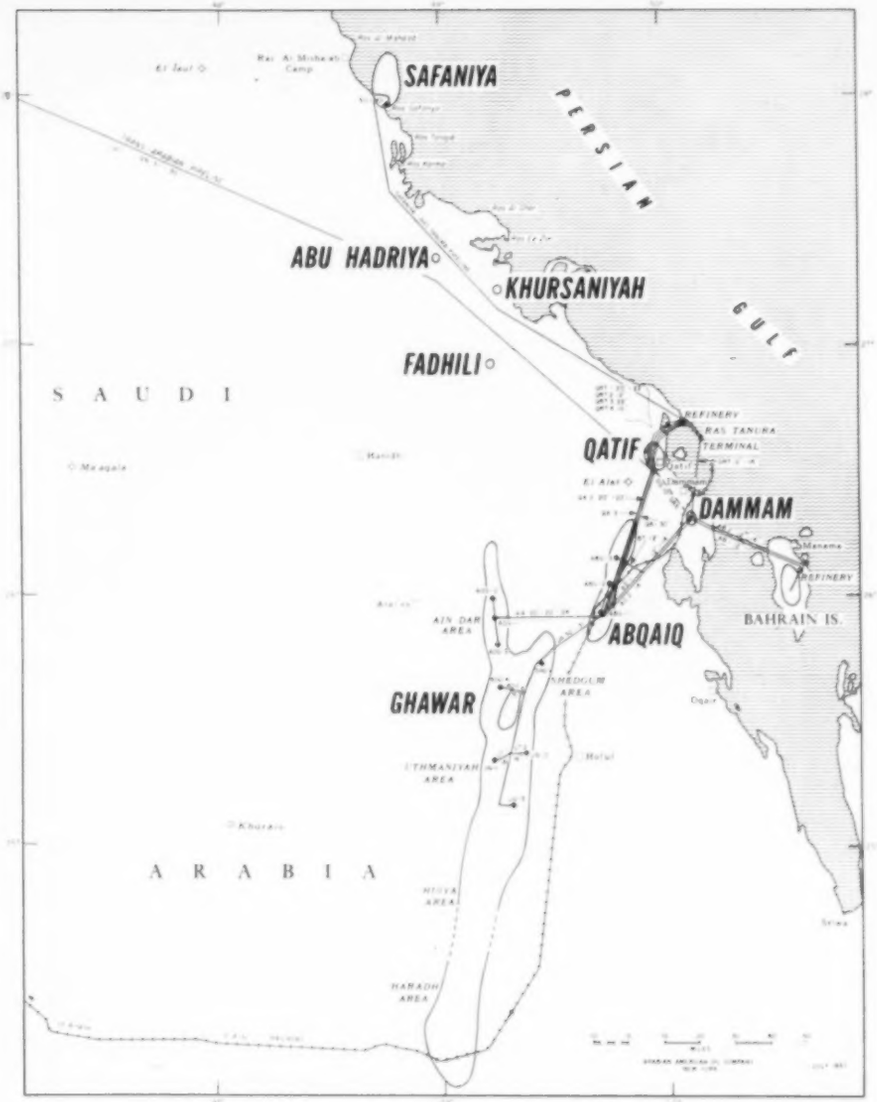
some ground beds have been equally spaced along the pipe line to assure the most economical degree of protection per unit of electricity supplied. If current is available in these locations, a rectifier should be used; if not, it is necessary to use other sources of direct current.

Magnesium anodes have been useful in Saudi Arabia for two locales. The first is in sea water installations where the relatively high conductivity of sea water makes it posible to derive full benefit from the magnesium. For example, a typical offshore Safaniya oil well, such as Well 16, will be cathodically protected by 24 fifty-pound anodes gathered in four clusters on the sea bottom and attached to the structure through copper-nickel alloy resistance bonds. These will usually protect the underwater portion of the well structure for from two to three years before needing replacement.

When the extensive underwater flow line system at Safaniya is completed, it may be possible to protect the well structures by bonding current from the cathodic protection system provided for these flow lines. Until that time, the magnesium anodes will be used to do the job. Other marine applications are the cathodic protection of drilling barges and isolated buoys and beacons. Two sizes of anodes are used in marine cathodic protection work: 50 and 200 pounds.

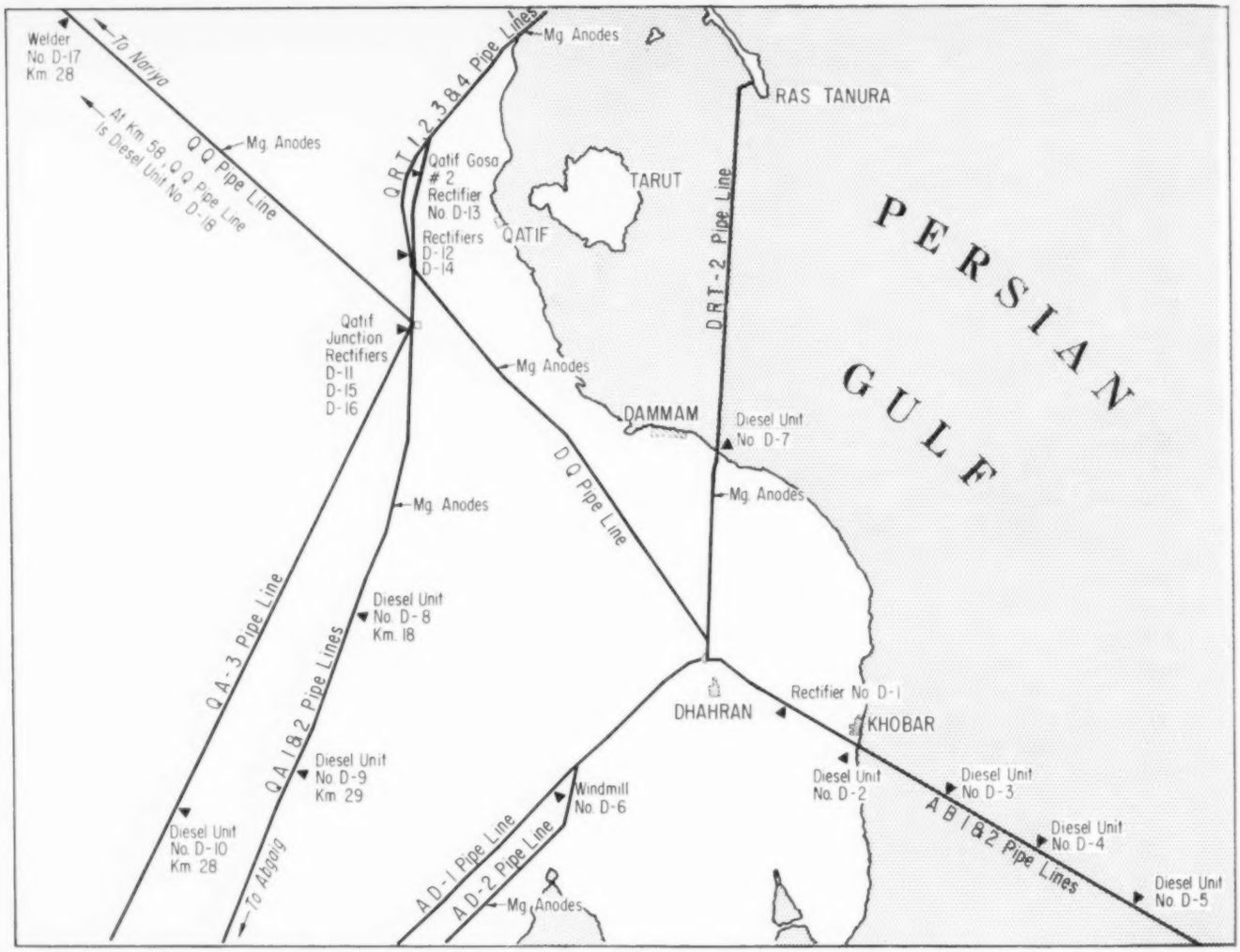
Soil Resistance Limits Output. On land, the chief deterrent to using magnesium anodes is the generally high resistivity of the soil. Practice has shown that sufficient current is not obtained from magnesium anodes when the resistivity rises above 3,000 ohm-centimeters. However, there is one class of region where the soil resistivity is generally low and that is the sabkha region. Certain of the older, smaller diameter oil lines are protected by magnesium anodes placed at strategic locations where the pipe lines traverse the sabkhas. The Abqaiq-Dhahran No. 2 (AD-2) is a good example of a pipe line protected completely by sacrificial anodes. It is a 12-inch pipe line with 50 percent of its 59 miles buried and protected by clusters of magnesium anodes.

Five years is the generally expected life of a magnesium anode installation. The results of most of the installations have been satisfactory. However, not all the desert regions are sabkhas and not all of pipe lines tra-



Aramco has 913 miles of oil pipe lines in Saudi Arabia; of this total 736 miles or 80 percent are buried and require cathodic protection. Lines vary in length from 4-mile Uthmaniyah (UT-1) gathering line to 270 mile, 30-31 inch Qatif-Qaismah (Q-Q) trunk line. More than 99 percent of these 736 miles are under cathodic protection.

Soil resistivities range from 800,000 ohm-centimeters to as low as 5 ohm-centimeters. Corrosion of the pipe is illustrated by this test coupon buried for two years without coating or cathodic protection alongside one of Aramco's pipe lines.



Cathodic protection units in the Ras Tanura and Bahrain area. Rectifiers are used wherever power is available. For isolated locations magnesium anodes, diesel generators and welding machines have been installed. In one location a windmill generator is operating on an experimental basis.

verse these areas. Also, the current required for adequate cathodic protection may necessitate a prohibitive number of anodes, making it necessary to resort to diesel generators.

Diesel Generators Serve Remote Locations. Although Aramco uses many kinds of diesel engines, only two types are at present used for cathodic protection power sources. Five older units are being used on the Arabia-Bahrain 1 and 2 (AB-1 & 2) submarine pipe line carrying sour crude oil under the Persian Gulf from the Arabian mainland to Bahrain Island. One is installed on each shore and the remaining three are spaced at about 5-mile intervals along the 16-mile pipe line. These generators are housed in corrugated shacks erected on steel pilings about five feet above the water level.

Engines Have Special Features. New diesel engine-driven generator units being used have the engine and generator mounted on a common bed plate for rigidity, with provisions for easy service and maintenance. The engine is designed to provide long and uninterrupted service in remote locations with a minimum of maintenance; it is a two-clyinder four-stroke, vertical, air-cooled unit operating at a speed of 850 rpm. A continuous output of approximately 12 bhp is provided at 300 feet above sea level and at an ambient temperature of 50° C. The engine was designed to withstand an overload to 14 bhp at the same ambient temperature conditions for one hour. All values are based on fuel oil of calorific value of 18,500 Btu per pound and a specific gravity below 0.9.

Special features of diesel engines:

- Cyclone filter with built-in wet filter for combustion air.
- Automatic spring loaded governor.
- Fuel injection pump for each cylinder built in one block.
- Auxiliary fuel feeding pump with priming valve.
- Air-cooled fuel nozzle for each cylinder.
- Two large size fine meshed fuel oil filters.
- Lubricating oil pump with pressure release.
- Air-cooled lubricating oil cooler (radiator type).
- Large size fine meshed lubricating oil filter with automatic cleaning device.
- Large size coarse meshed lubricating oil filter.
- Large size shunt connected lubricating oil filter.
- Pressure gage for lubricating oil.
- Lubricating oil pressure safety device.
- Nickel-Cadmium type starter battery, 12 volt.
- Starting switch and a signal lamp for charging control.
- High-pressure blower driven from the crankshaft which supplies all necessary cooling and combustion air and which is designed to over-

ome the pressure drop due to the ir filters.

- Thermostatically controlled preheater for fuel oil.
- Recording type hour meter to record actual hours of operation.
- Supplementary lubricating oil tank.
- Automatic safety-stopping device.

The safety device will start the shunt field motor in case the dynamo does not supply enough current and will come into operation when the lubricating oil pressure has decreased below its limit.

Generator Designed for Area. A totally enclosed, ventilated shunt type d.c. generator is used. It is horizontally mounted with provision for a direct coupling to the diesel engine by means of a semi-elastic coupling. The cooling system is designed in such a way that the cooling air from the diesel engine blower cools the subhousing of the generator only. Air does not pass through the generator where sand or dust causes serious trouble with the brushes and the commutator.

Rating of the generator is 60 volts, 110 amperes, with a continuous output of 6.6 kw at 50° C.

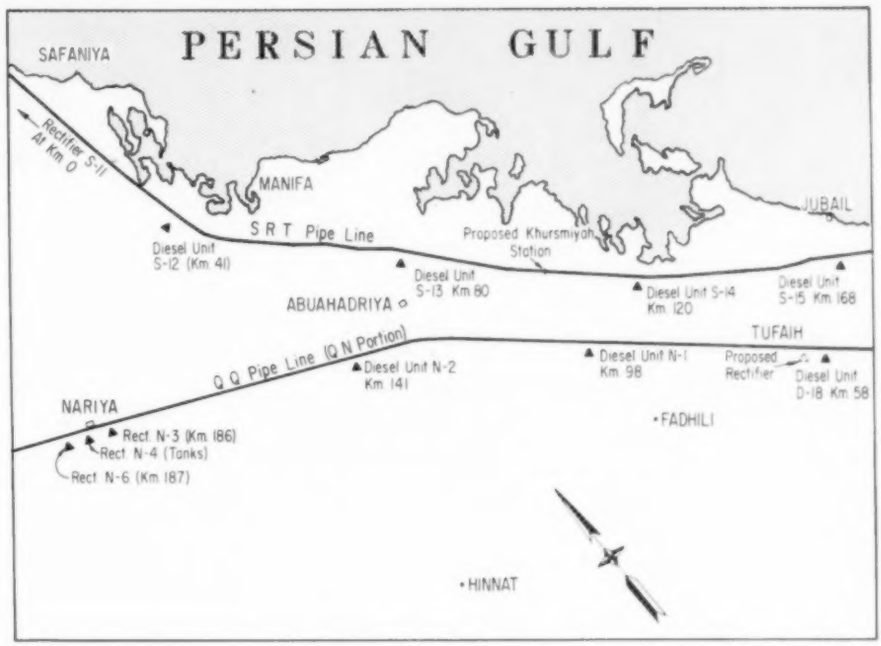
The d.c. switchboard is mounted on the generator frame and is equipped with the following devices:

- Hand-operated field rheostat for regulation to 40 percent of the rated voltage.
- Ammeter with range 0-150-A.
- Volt meter with range 0-75 volt.
- A general purpose fusible, 2-pole, quick acting safety switch, 200 amp. frame with 125 amp. and 250-volts fuses for overload protection.

Air-Cooled Units Most Practical. Air to the diesel engine is filtered in four stages before entering the engine. Combustion air is filtered initially by three stages of impingement type filters and finally by an oil bath type filter mounted on the engine, a belt-driven blower is provided to overcome the pressure drops across the filters and to insure an adequate supply of both cooling and combustion air.

Air-cooled slow-speed diesel equipment was selected for this application for the following reasons:

- It is independent of water supply.
- This type of diesel is adaptable to all variations in climate.
- A slow-speed unit will require far less maintenance and provide longer continuous service than a higher speed unit.



Cathodic protection units in the Safaniya area. Offshore gathering lines and lines passing through depressions called sabkhas where highly saline waters are near the surface are critical areas. Aramco has 44 rectifiers in operation on their pipe line system.

Welding Units Furnish Temporary Power. Gasoline engine-driven arc welders have proved to be satisfactory for use in temporary protection of the pipe lines while permanent equipment is being procured. If the semi-annual surveys of the pipe-to-soil potential differences of any of the pipe lines show extensive portions below the —.85 volt level, it is Aramco's practice to dig a temporary anode bed and to connect a welding machine to the line. At the present time, there are seven welders installed, five on the Qatif-Qaisumah (Q-Q) pipe line and two on the Uthmaniyah-Abqaiq pipe line.

Chief advantage of these units is their flexibility of installation and replacement. They are, however, somewhat expensive to operate and normally require the services of a permanent watchman. Permanent diesel units, requiring refueling only every three months and being unattended, are more attractive from the maintenance viewpoint.

Windmill Generator New Power Source. The newest form of cathodic protection now in use by Aramco is the windmill generator. Only one is in operation and it is still classed as experimental. It is erected about halfway between Dhahran and Abqaiq on the 12-inch Abqaiq-Dhahran No. 1 (AD-1) pipe line. At the present, it adequately protects about five miles of buried pipe line in an area containing both sabkha and sand.

It has operated satisfactorily since January, 1957, with not more than a day or two when the blades were not turning. However, since the winter and spring are usually more windy than the summer months, it will be necessary to gather data for a whole year's operation before making the windmill standard for short-line protection in Arabia.

Aramco's Corrosion Policy. The organization of the cathodic protection activities follows along the same lines as that of the other operating functions. An engineer in each of Aramco's three districts is assigned to cathodic protection activities in his own region. Process engineers are used in the Dhahran and Abqaiq districts; an electrical engineer from the Inspection department is used in the Ras Tanura district. Unattended units are serviced by the pipe lines section of the Oil Operations department; usually one or two mechanics per district are assigned to the repairs and maintenance of the units.

The pipe lines are patrolled semi-weekly by truck and once per week by airplane; records are kept of leaks found and repairs made. Extensive surveys for "holidays" are made

(Continued on Page 50)

Rules of Thumb

and Engineering Data Sheets for the Pipeliner's field notebook

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These practical aids give quick, reasonably accurate answers to design, maintenance and cost estimating problems. PIPE LINE INDUSTRY will pay $25 for each chart, nomograph or data sheet published—$15 for each Rule of Thumb. Send your ideas to PIPE LINE INDUSTRY, P. O. Box 2608, Houston, Texas

Engineering Design —51—Allowable Working Pressure for Carbon Steel Pipe

Based on formula No. 7 of the ASA Code for Pressure Piping, Section 3B, this table was computed for 6⅝-inch O.D. to 36-inch O.D. carbon steel seamless pipe, API Specifications 5L Grade A, 5L Grade B, and API 5LX Grade X-42.

The formula is:

$$t = \frac{PD}{2(S + YP)} + u + c$$

where:

t = wall thickness, inches
P = allowable working pressure, psi
D = outside diameter, inches
S = allowable stress, psi
Y = a coefficient
u = under-thickness tolerance, inches
c = allowance for threading, mechanical strength, and corrosion, inches

In calculation of the tables the values of Y, U and c were:

Y = 0.4
u = 0.125 t (u = 12½% of t)
c = 0.050-inches

Substituting in formula and solving for P:

$$P = \frac{1.75\ S\ (t - 0.057)}{D + 0.04 - 0.7\ t}$$

The S-values are
Spec. API 5L Grade A — 25,500 psi
Spec. API 5L Grade B — 29,750 psi
Spec. API 5LX Grade X-42 — 35,700 psi.

Example—Find pipe specification for a 12-inch line operating at 1,078 psi: In the 12¾-inch column these conditions will be met using Grade X-42 pipe with 0.281-inch wall thickness, Grade B pipe with 0.330-inch wall thickness, or Grade A pipe with 0.375-inch wall thickness.

Idea submitted by
Jose Pedro Alvim
Petroleo Brasilerio S. A.
Rio de Janeiro, Brazil

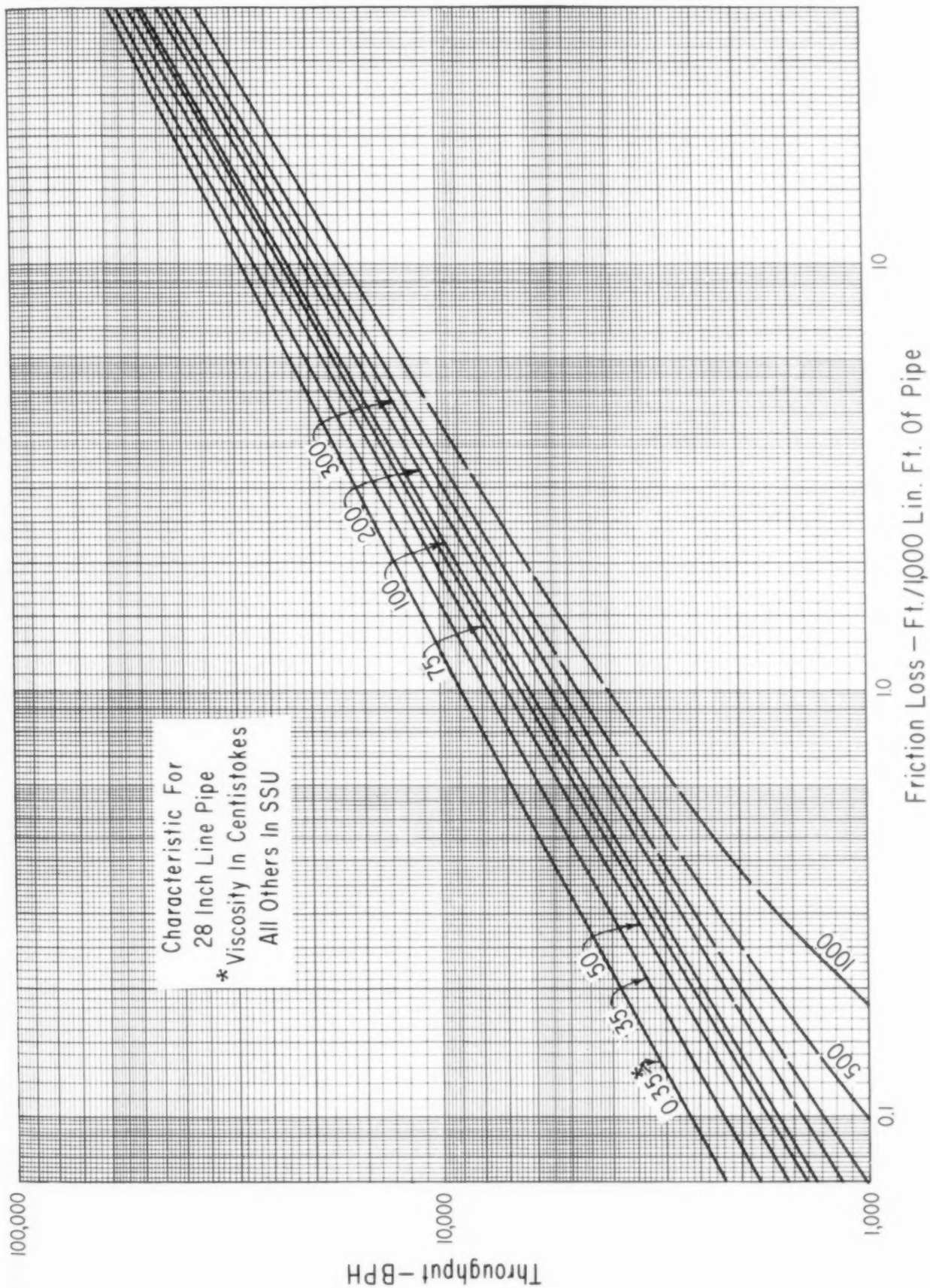
O.D. / Wall Thickness	6⅝	8⅝	10¾	12¾	14	16	18	20	22	24	26	28	30	32	34	36	O.D. / Wall Thickness
0.188	895 1044 1253	685 799 959	548 640 768	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	0.188
0.203	. . . . .	1070	857	721	. . . . .	. . .	. . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	0.203
0.219	1110 1295 1554	849 991 1189	680 793 952	572 667 801	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	0.219
0.250	1327 1548 1858	1014 1184 1420	811 947 1136	683 797 956	621 725 870	543 633 760	482 562 675	434 506 607	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	0.250
0.281	. . . . .	. . . . .	. . . . .	794 926 1111	722 842 1010	631 736 883	560 654 784	504 588 705	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	0.281
0.312	1765 2059 2471	1347 1572 1886	. . . . .	905 1056 1267	823 961 1153	719 839 1007	638 745 894	574 670 804	521 608 730	478 557 669	441 514 617	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	0.312
0.344	1994 2326 2791	1520 1774 2128	1214 1416 1700	1021 1190 1429	928 1083 1299	810 946 1135	720 839 1007	647 755 906	587 685 823	538 628 753	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	0.344
0.375	2216 2568 3103	1689 1970 2364	. . . . .	1133 1322 1586	1030 1202 1442	900 1049 1259	798 931 1118	718 837 1005	652 760 912	597 696 836	551 642 771	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	0.375
0.406	. . . . .	. . . . .	. . . . .	1744	. . . . .	. . . . .	1228	1104	1002	918	847	786	733	687	646	610	0.406
0.438	. . . . .	2034 2373 2848	1622 1892 2271	1362 1589 1907	1238 1444 1733	1081 1261 1513	959 1119 1342	862 1005 1206	782 913 1095	716 836 1003	661 771 925	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	0.438
0.500	. . . . .	. . . . .	. . . . .	. . . . .	1444 1685 2022	1260 1470 1764	1118 1304 1565	1004 1171 1406	911 1063 1276	834 974 1168	770 898 1077	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	0.500
Wall Thickness / O.D.	6⅝	8⅝	10¾	12¾	14	16	18	20	22	24	26	28	30	32	34	36	Wall Thickness / O.D.

Engineering Design —52—Head Loss Charts for Various Sizes of Pipe

Friction Loss Charactistics for 28-inch pipe were computed by a pipe line company using data of the Hydraulic Institute. Use of these data in laminar and critical zones is adequate for estimates. Friction losses in transition and complete turbulent zones are very accurate.

(Chart 13 in a series of 19—28-inch line pipe)

ENGINEERING DESIGN 52



Thinking—An Elusive Art

Today, there is growing concern that too many executives are reulctant to think. How well do you think? This article will test your reasoning power.

THINK. Throughout America that word, displayed in large letters on a mahogany board, can be seen gracing the office walls of countless industries. The originator of this motto, in his most prophetic moments, could not have foreseen the wholesale disregard of his admonition.

At least one expert on mental gymnastics has said, "Five percent of the population thinks; 5 percent think they think; and 90 percent had rather die than think."

By the same token, there is evidence in industrial discussion of a growing concern within management over the problem of motivating junior and senior executives to THINK. Many members of top management have expressed certain misgivings over the fact that while the everyday decisions and reports made by their executives are admirable in content and organization, the majority are evidently playing it safe; they seem reluctant to think.

Beware These Think "Killers." The question arises: is this group capable of thinking or has its initiative been suppressed by rejection of former "thinking" solutions to everyday problems? In many cases it is suspected that the latter is true.

Has the excitement of executive decision-making given way, due to rejection and pressure to conform, to a routine carrying out of assignments? Has the executive been encouraged to think (other than hanging a sign on his wall)?

Another contributing factor to the "killing" of thinking in the executive is the organization of functions into hierarchies with specialization of function to get mass production. This is known as bureaucracy. And one of the basic problems of bureaucratization should be seriously considered. That is its stultifying effect upon executive thinking.

Thinking can only survive in the fertile field of spontaneity and a reasonable degree of individual freedom. Therefore, to teach an executive to think, he must first be allowed the necessary freedom to disagree and "think" through the solution to the problem. Paralyze the executive in his thinking about the fundamental problems of his present position and he will hardly be ready to throw himself with enthusiasm into the higher executive positions. This will become more apparent as we look further into this "thinking" subject.

Why Think? The basic reason for the executive to think is to solve problems and make recommendations. This is in contrast to the executive who continues to carry out assignments but only because he has found it easy to do just what his supervisor wants.

In addition, thinking will help him formulate beliefs about existing and future solutions of problems. Thinking also affords the executive enjoyment. With a well-stocked mind he can imagine new situations and take pleasure in reviewing past successes. While reviewing the past problem-solving successes new ideas will emerge and contribute to the solution of other problems.

Before we can teach a person to think, we must know what we are teaching. A definition then, is in order.

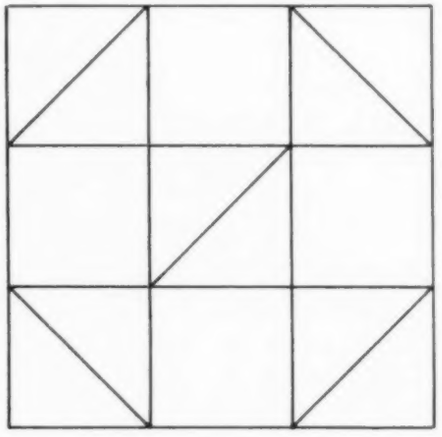
Reverie and Reason. Thinking is a sequential arousal of symbols. These symbols or "ideas" are based on knowledge or recall of the past. The more experience an executive has in solving problems the more ideas he can recall and apply to new problems. These symbols may be words, images, gestures, ideas or final consequences of past actions.

There are two main types of thinking. Reasoning and reverie. In reverie the thinking is random, as in daydreaming. This type of thinking adds little to realistic problem solving.

On the other hand, reasoning is constructive because it is directed and controlled. The reasoning begins with a problem and ends with its solution. As an example, if the problem is to get an unworking automatic washer started, we think of things that might be amiss with the washer, not of unrelated things as in daydreaming.

Three "Think" Stimulators. In teaching an executive to think, certain types of mental problems can be used. Whether the problem itself is related to his work is immaterial at first.

1. The first consideration is that he recognize the steps and freedoms he must use to solve the problems. Present the drawing shown below with instructions to trace each line with-



out repeating any line or raising the pencil from the paper.

You will notice that there is a tendency to begin in the upper left hand corner. This is generally due to past experience in reading habits and, if used in this case, makes success impossible.

This tendency, to let past habits shackle thinking, is probably the greatest handicap to successful problem solving.

The executive who can pull himself away from the left to right reading habit and make shifts and wide variations on this particular problem is on his way to being a successful thinker.

2. Another deterrent to productive problem solving is a preconceived notion or assumption. If the executive cannot use materials or ideas in new ways or discard the preconceived notion he is limited in his ability to think through and solve problems. Use the following problem to test your "pupil."

Provide a string of beads consisting of two colors. The problem is to regularize the color pattern without unstringing or restringing them or breaking the thread. The string, with a square representing black and a circle representing white, should be presented as follows:

○■■○■■■■■○■■○■■

Of course, the solution is to do away with the three extra black beads in the center. The only solution is to break the beads with some available "tool." To do this the executive will have to overcome his "preconceived notion" that the beads, too, must not be broken. This, of course, is not the case and was not in the instructions.

After working such problems this "breaking away from the preconceived notion" will become a working tool in future problem solving.

3. Another problem to test an executive's ability to avoid unnecessary assumptions is done with six matches. The instructions are to make four equilateral triangles without breaking the matches. If the executive assumes that the construction will lie in a plane he will be unsuccessful. He will probably say you "tricked him" when you show him the following solution.

The fact that he did not "think" of this 3-D solution to the problem shows that he made an unnecessary assumption. As stated before, executive thinking depends upon "freedom" of thought. If past habits, notions and unnecessary assumptions are hampering the executive's thinking then his attention can be called to it by the use of the above problems. Such problems call for turning and twisting and some detouring, which is contrary to a person's natural feeling of straight forward progress.

But it is this mental ability to deviate from past habits and natural inclinations that makes an executive valuable in problem solving.

These exercises will reveal to the executive the progress of problem solution. First, of course, the problem presents itself, a "hunch" or hypothesis emerges, and then a trial run or test of the hypothesis. In other words, the executive must see what there is to be done and what there is to work with.

The measure of how deeply and broadly the executive thinks in regard to the material with which he works, can be ascertained.

Shallow vs. Deep Thinkers. For example, the shallow and narrow thinker is more apt to stick to the common use or definition of an object or idea. When asked to enumerate the uses of a lead pencil he will usually respond with, "To write and to erase."

An executive with depth and breadth of thinking will list many uses. Such as; to write, to erase, to poke, as a lever, as a pin, as a splint, and many others.

A thinking executive will use materials and ideas at hand in many ways for which they were not originally intended. This ability to see new uses for old material and ideas in the solving of current problems is an indication that the executive is following the motto: THINK.

However, it must be remembered that, taken by itself, thinking has no responsibility. It is not an end product; it is essentially a mechanism which has been found to be fundamental to the fruitful operation of any business.

An executive must also remember to "think about his thinking." Or he may find himself on the bosses' carpet saying, "I thought, without thinking, that . . ."

Avoid "Blind" Thinking. If random, blind groping, trial and error thinking is used there will be many false steps, valuable time wasted and possibly minor disasters. However, controlled trial and error, that is the trying of various ideas because of inability to see in advance which idea will prove successful, can be used to advantage.

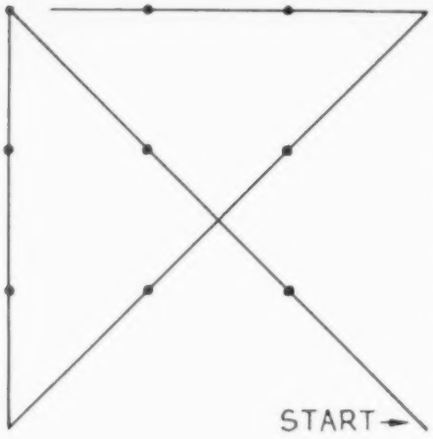
In using this method the executive is trying only the combination of ideas that makes sense. There may be many false leads, but there would be no irrelevant behavior such as trying every idea that popped into mind.

In trying different ideas in the solution of a problem a restricted "mental set" can interfere to the degree of prohibiting a solution altogether. The following problem will illustrate how a restricted (by boundaries) mental set can interfere with the correct answer.

The instructions are to connect the nine dots by drawing four straight lines without raising the pencil from the paper or retracing. Using controlled trial and error one idea after another is tried. All ideas that concern the dots and does not comply with the instructions are discarded. This is a necessary mental set.

But there may be another mental set not concerned with the instructions. This is the set that restricts the lines to the area bordered by the dots. As long as this type of thinking prevails the problem will not be solved. But when the mental set is broken and "free" thinking makes it possible for

the lines to go beyond the boundary of the dots, a solution can be found.



This emphasizes the importance of going beyond everyday habits and routine thinking. And, to repeat, such problem solving calls for "freedom of thinking."

Concrete vs. Abstract. In addition to the above diagrammatic problems, language problems can be used. In fact, linguistic problems compel the executive to use additional mental processes in his thinking.

Major among these is imagery. When confronted with a language problem a mental picture (image) must be "drawn" because none has been supplied as in the diagrams used above.

Language problems, such as the one below, come closer to the realistic problems the executive faces than does the diagrammatic. For, generally, everyday business problems are not neatly drawn out with a set of instructions attached.

Before presenting the following language problem the executive should be cautioned to avoid the "mental pitfalls" encountered while working the diagrammatic problems.

A traveling salesman ran out of money while staying at a motel and his expense check would not arrive for 23 days. He suggested to the proprietor that he be allowed to pay his daily bill with a heavy gold watch chain of 23 links. The proprietor agreed to accept a link on each successive day and return the chain when he received his money. How many links does the salesman have to cut in order to pay his bill? The answer is 2 links.

After divulging the correct answer the real problem arises. How did one arrive at such an absurd answer?

In solving this second problem the executive will have to look at the stated facts in different ways, seek new meanings and look for new combinations. Otherwise speaking, he must develop mental flexibility. Eventually he will find that 2 *is* the correct answer.

Another language problem that brings forth still another mental process is the one which leaves out, so it seems, some necessary directions. The final question seems completely disconnected from the stated facts. For example:

A hunter left his camp one morning and walked one mile south. Then he turned west and walked one mile and shot a bear. At that point he was an equal distance from camp as when he turned west. What color is the bear?

At first examination there seems to be no clues in the given facts as to the color of the bear. Upon closer scrutiny, and more important, after giving "freedom" to the thinking processes the answer suddenly appears.

In solving such problems the solution comes by proceeding from the concrete to the abstract. Abstracting is observing the similarity of otherwise different things. Such flexibility, in many instances, must be taught.

The aim of this article is not to exhaust the topic of thinking, but to indicate rather generally and by a few examples a partial solution to the problem of teaching executives to think. As stated previously, they cannot think if they do not know how or if they are not allowed mental freedom.

The foregoing is a suggested way to bring the attention of the executive to the proper process of thinking. This may enable him to address himself in a spirit of confidence to the central business problems of our time.

Executives do not need to be prodded to face up to these problems—they will be ready enough to do so if given a measure of freedom, instructions, and backing.

Members of top management can help by pointing out that such freedom and backing is precisely what the executive can expect. By speaking out in this way they would help to lift a little the weight of uncertainty that now chokes off thinking. —**The End**

Aramco Protects Pipe Lines

Continued from Page 45

in areas when leaks occur with any frequency; as a result of these surveys a recoating program is under way in some pipe line sections.

In sum, the progress of corrosion has been checked by the present activities in cathodic protection of Aramco's Saudi Arabian installations. Newer pipe lines have cathodic protection equipment as an integral part of their design; experience in operating generators and rectifiers under desert conditions has helped in the selection of the correct equipment; holiday surveys have led to the pinpointing of critical locations on the pipe lines. Further progress in cathodic protection will undoubtedly lie in the direction of protecting land flow lines, oil wells and tanks. Since the soil in Saudi Arabia is just as corrosive as it is in America, the same means of protection have to be used. —**The End**

About the Author

Edward G. Peattie, process engineer who specializes in corrosion, checks up on Arabian American Oil Company's windmill generator (background) on the Abqaiq-Dhahran line. The experimental windmill generator is the newest form of cathodic protection now used by Aramco in Saudi Arabia. Before joining Aramco in 1954, Peattie specialized in coating and corrosion work with the U. S. Navy, Glidden Company, and Firestone Rubber Company. He received an M. S. degree in chemical engineering from the University of Michigan, an M. A. degree in English and chemistry from Temple University, and studied special courses in TNT chemistry at Lehigh University and rubber chemistry at the University of Akron.

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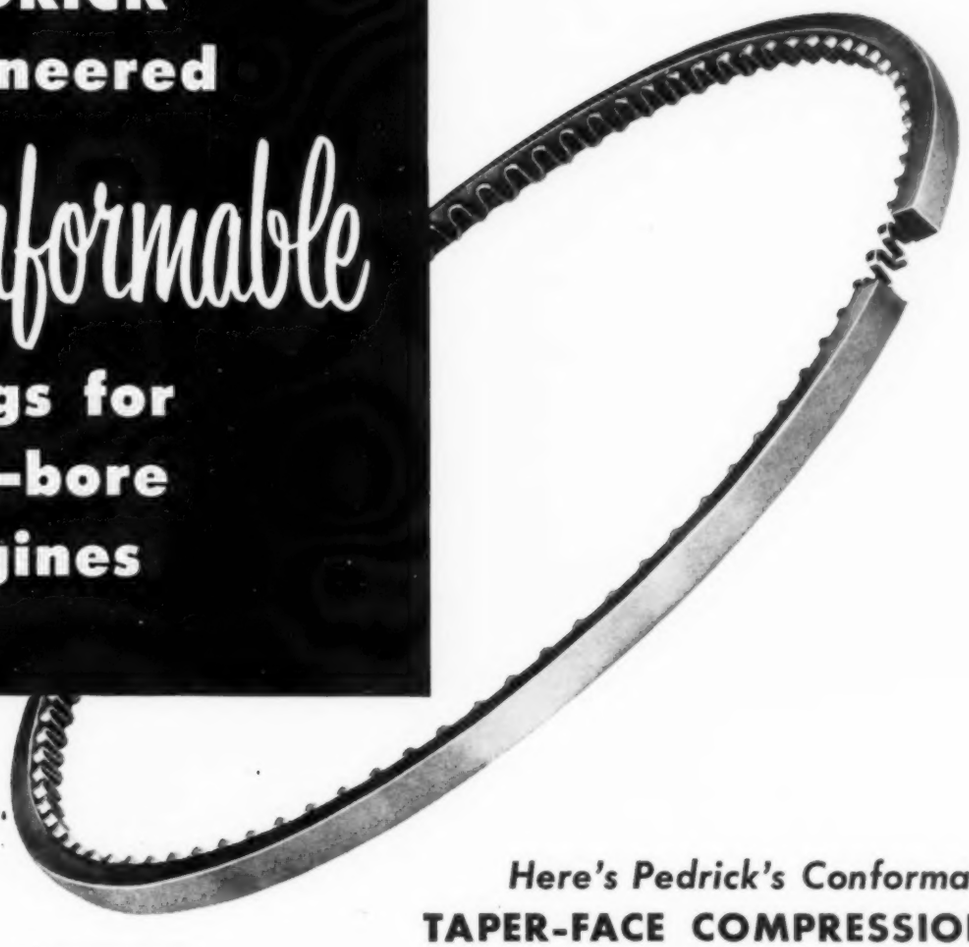

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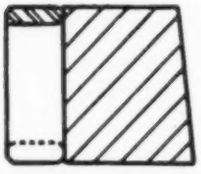

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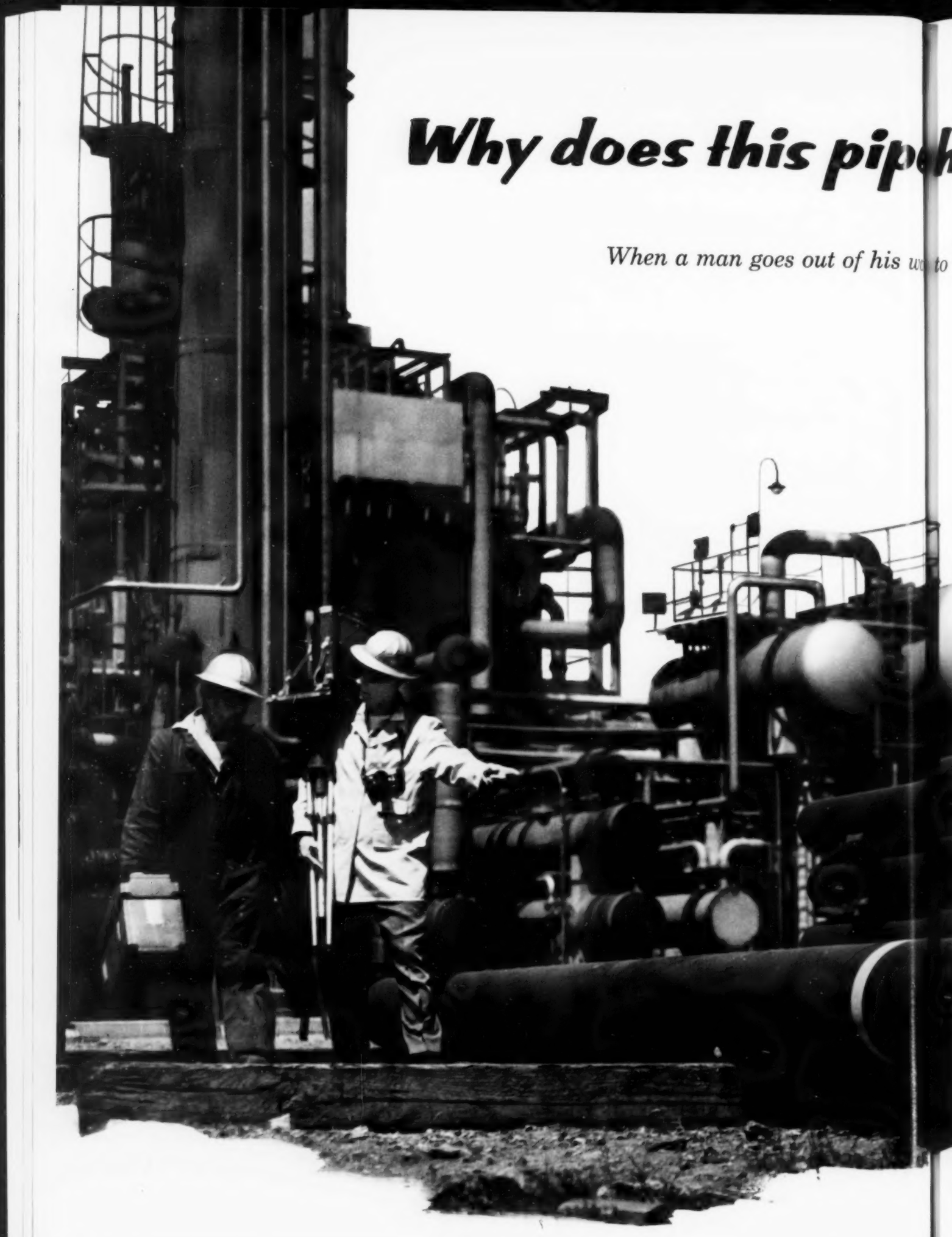

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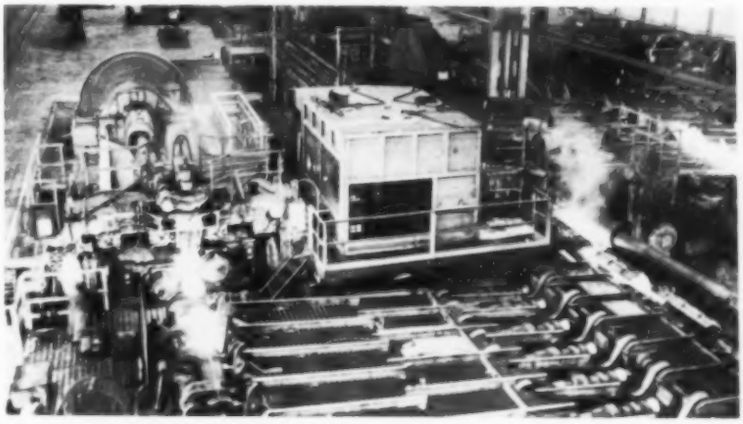

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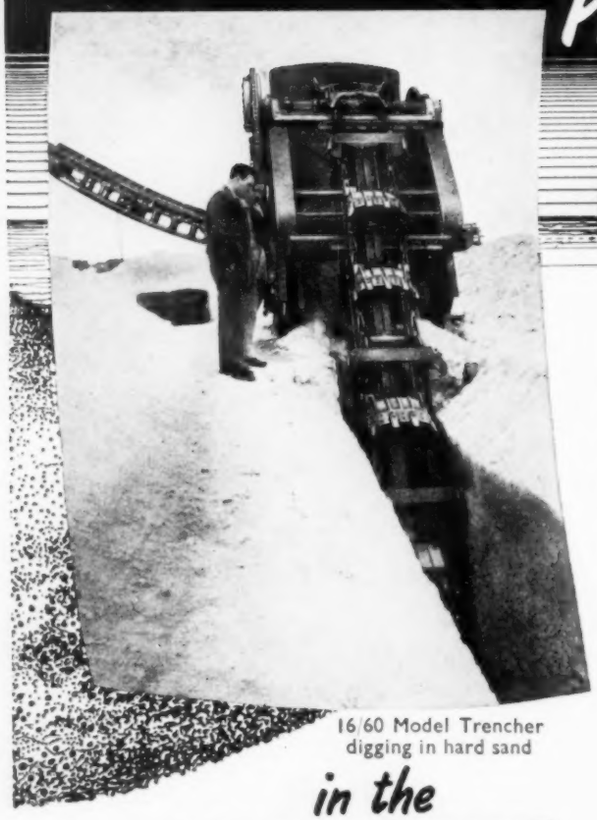

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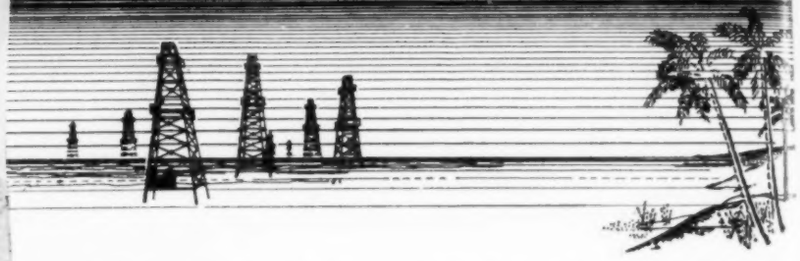

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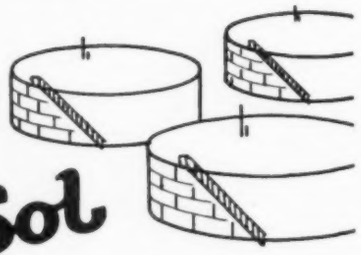

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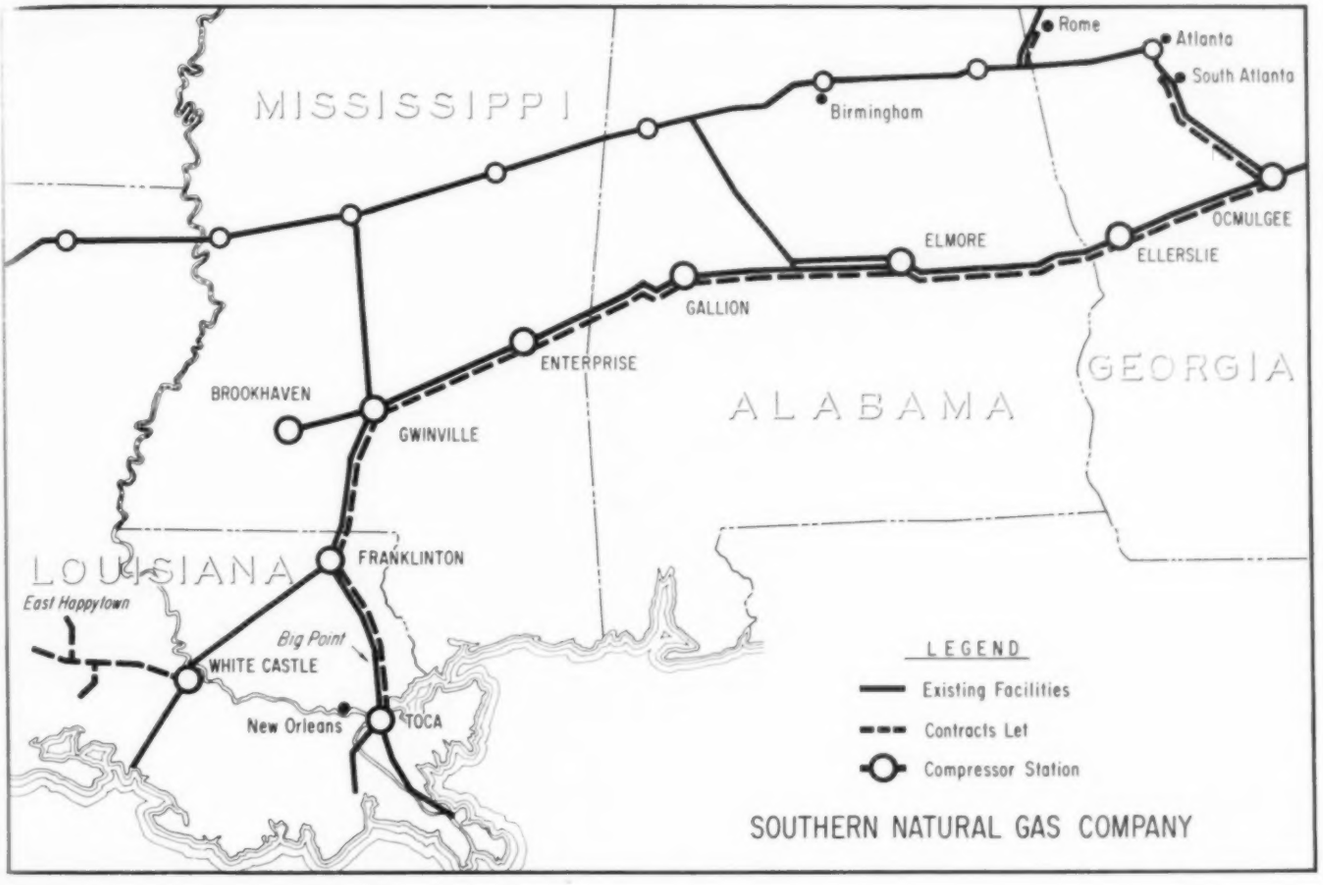
WHAT'S HAPPENING

IN PIPE LINE CONSTRUCTION

By **Donald G. DePugh,** PIPE LINE INDUSTRY Staff



Southern Natural Gas Company Awards Four Contracts For Construction of 516 Miles of Loops and Laterals

Southern Natural Gas Company has let contracts on a major portion of its $110 million expansion program for 1958-59.

A total of 516 miles of 14- and 26-inch pipe line will be constructed in Louisiana, Mississippi, Alabama and Georgia. Southern Natural has received Federal Power Commission authorization on a part of this project but is awaiting approval on over 300 miles.

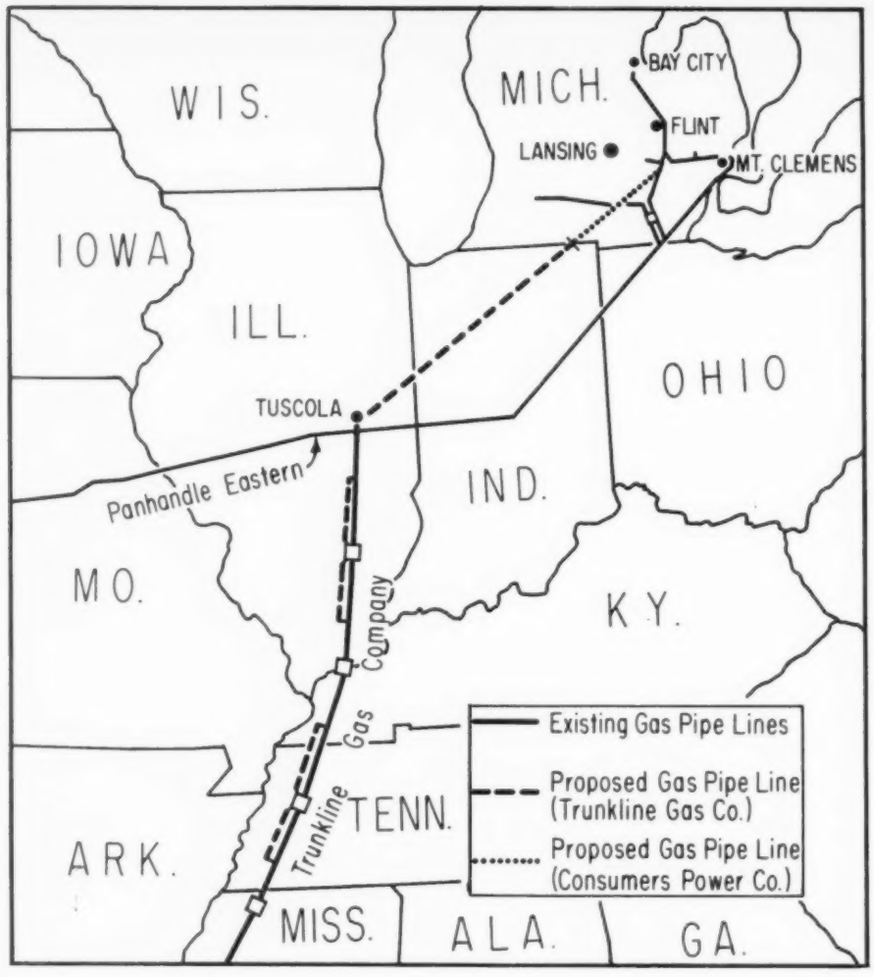
Successful bidders and their mileage are William Brothers, 41 miles, 24-inch; River Construction Corporation, 124 miles, 24 and 26-inch; H. C. Price and Houston Contracting Company, joint contract, 276 miles, 14- and 26-inch; and Western Pipe Line, Inc., 74 miles, 20- and 24-inch.

Contracts were awarded for main line and lateral loops extending from the Toca station in South Louisiana to Atlanta, Ga. Southern Natural's over-all expansion will include over 1,200 miles of main line loops, branch line loops, supply laterals and offshore lines. This year's construction includes additional horsepower at White Castle, 1,100 hp, Toca, 4,000 hp, and Franklinton, 1,350 hp. Further compressor horsepower additions for 1959 include 3,880 hp at Patterson, La., and Brookhaven, Miss., and 3,140 hp at Gallion, Ala., Elmore, Ala., and Wrens, Ga.

Western Pipe Line will lay 28 miles of 24-inch between Toca station and Big Point, La. and 40 miles of laterals extending west from White Castle to East Happytown. Williams Brothers' section extends from Big Point to Franklinton, La. River Construction will construct 68 miles, 26-inch, from Franklinton to Gwinville, Miss., and 57 miles, 24-inch, from Gwinville to Enterprise, Miss. Houston Contracting and H. C. Price spreads include 63 miles, 24-inch, from Enterprise to Gallion, Ala.; 57 miles, 24-inch, Gallion to Elmore, Ala.; 47 miles, 24-inch, Elmore to Ellerslie, Ga.; 46 miles, 20-inch, Ellerslie to Ocmulgee station, Ga.; 40 miles, 14-inch, Ocmulgee to South Atlanta, Ga. and 23 miles, 14-inch, south of Rome, Ga.

Southern Natural plans for next year include looping sections between Ocmulgee station and Wrens, Ga.; White Castle and Franklinton stations; and construction of 20 miles of supply line from Patterson to the Gulf Coast.

Contracts will be let soon on the remaining portion of this proposal.



Trunkline Proposes 204-Mile Extension

Trunkline Gas Company has proposed an $81.5 million construction program which will increase the company's capacity by 135 MMcf daily.

In its application to the Federal Power Commission, Trunkline proposed to build a 204-mile, 26-inch, extension of its main line from Tuscola, Ill., to the Indiana-Michigan border where it will connect with Consumers Power Co.'s proposed line.

Trunkline also will install 3,000 additional horsepower at its Longville, La., station and construct 464 miles of 30-inch loops between Longville and Tuscola, plus 45 miles in Texas. Some 183 miles of gathering lines will be added in Texas and Louisiana—of which a portion will be offshore.

"The Trunkline expansion is designed solely to supply Consumers Power Company, and there is no plan to attach other customers," said President W. K. Sanders. Consumers plans to construct a 120-mile, 26-inch line from the Michigan-Indiana border to Plymouth, Mich., near Detroit, to serve its Michigan distribution system.

The Trunkline project is the first step in an over-all program to supply 200 MMcf of gas daily to Consumers. Construction will start January, 1959, and be completed in time to provide gas to the Michigan area for the 1959-1960 winter season.

Houston Contracting Gets Gulf Interstate Project

Houston Contracting Company has been awarded a contract by Gulf Interstate Gas Company for construction of 54 miles of 24-inch loop lines in the vicinity of Rayne, La.

Work will get underway in November and will be completed by January.

This is part of a 400-miles expansion program for Gulf in Kentucky, Mississippi, Tennessee and Louisiana. Houston Contracting and H. C. Price are constructing the 350 miles of 30-inch which should be completed by 1959.

NGPL Awards Contracts On 511 Miles of Loops

Natural Gas Pipeline Company of America has let contracts on its $ 2 million expansion program to supply an additional 100 MMcf of gas daily to the Chicago area.

R. H. Fulton & Co., Williams Brothers, Inc., and Contracting and Material Company will construct 4[illegible]3 miles of 36-inch and 21 miles of 2[illegible]-inch pipe line between Fritch, Texas, and Joliet, Ill. Construction will start August 1, and completion is expected by January, 1959.

Fulton has been awarded contract for the section from Fritch to a point near Meade, Kan., which includes 205 miles of 36-inch and the 21 miles of 26-inch.

Williams Brothers will build the 106 mile, 36-inch, portion between Haddam, Kansas, to Weeping Water, Neb., area and 99 miles from Mt. Etna, Iowa, to a point west of Knoxville, Iowa.

Contracting and Material will lay 81 miles of line west of Muscatine, Iowa, to the Princeton, Ill., area.

The Federal Power Commission has authorized a 100 MMcf daily increase for NGPL. The company presently is taking steps to show the Commission its ability to supply the additional 85 MMcf it requested in its application presented to the FPC.

The additional facilities will bring NGPL's total pipe mileage to more than 3,700.

Natural Gas Pipeline Company still has pending before the FPC an application to increase its deliverability by an additional 485 MMcf. This project includes looping the same segments of the line. The proposal includes 416 miles of 36-inch and 396 miles of 30-inch.

Contracts Are Awarded On Eastern Shore Job

Eastern Shore Natural Gas Company has awarded contracts on its 145-mile, 6 and 8-inch gas line in Delaware and Maryland.

Fulghum Contracting Company and Buchanan Pipe Line Construction Company will build the line. Fulghum has the northern section and Buchanan has the southern portion. The $3 million project will increase deliverability of its distribution system in Pennsylvania, Delaware and Maryland.

Canadian Company Files Application For Edmonton-to-Montreal Crude Line

Independent Pipe Line Company of Canada filed a proposal with the Borden Commission for construction of a 2,019-mile 34 and 36-inch crude line extending from Edmonton to Montreal.

The $395 million project includes a 145-mile 10 and 16-inch lateral line from Calgary which will connect with the line at Bellshill Lake.

Plans call for installation of six pump stations totaling 23,000 horsepower to provide a thoughput of 259,000 bbl. per day. Fourteen additional pump stations are planned by 1970 to increase the horsepower to 193,000 and boost the capacity to 733,000 bbl. daily at Bellshill Lake, 527,000 at Superior and 410,000 at North Bay, Ontario.

The 36-inch section of the line will be 1,073 miles running from Edmonton to Superior, Wis. The link between Superior and Montreal consists of 946 miles of 34-inch. If approved, the line will be constructed by 1961.

Independent producers proposing the line claim Alberta crude can be delivered to Montreal at $3.145 per barrel compared to the $3.077 to $3.28 a barrel paid for Middle East and South American crudes.

R. A. Brown, Jr., Independent Pipe Line Company and Home Oil Co. president, told the Borden Commission that government help is needed to persuade the Montreal refiners to take Canadian crude in place of foreign crude.

Independents hope to deliver crude to Interprovincial Pipe Line Co. at Superior delivering 29,400 bbl. daily in 1961 and reaching 202,000 bbl. by 1970. The independents' market study allowed for exports to the U. S. Midwest amounting to 80,000 bbl. a day in 1960 with the capacity of 125,000 in 1970.

Crude at Calgary will be supplied by Britamoil and Cremona pipe lines. Increased production in the Pembina, Leduc, Redwater, Acheson and Golden Spike fields will account for the crude supplied at Edmonton.

Independents backing the project include Canadian Devonian Petroleums, Canadian Homestead Oils, Canadian Exploration, Colorado Oil & Gas Co., Consolidated East Crest, Consolidated MicMac, Home Oil, Medallion Petroleums, Merrill Petroleums, Okalta Oils, Westburn Oil Co. and Western Decalta Petroleums.

Interprovincial Pipe Line Company has proposed a 350 main line extension to its crude line from Toronto to Montreal and looping its line from Edmonton to Toronto to bring crude to the refinery area. Interprovincial claims it would be more feasible than building a new line.

Wabash Lets Contracts on 265-Mile Products Line

Wabash Pipe Line Company has let contracts on a 265-mile, 12-inch products line from Wood River, Ill., to East Chicago, Ind.

Contracting and Material Company will build the line which will tie into an 85-mile common carrier from Robinson to Champaign, Ill.

Wabash was formed by Ohio Oil Company and Continental Oil Company to build and operate over 350 miles of products lines. Ultimate capacity of the system will be from 90,000 to 100,000 bbl. per day. Outdoor electric pump stations are planned at Wood River, Robinson and Champaign, with others to be added later.

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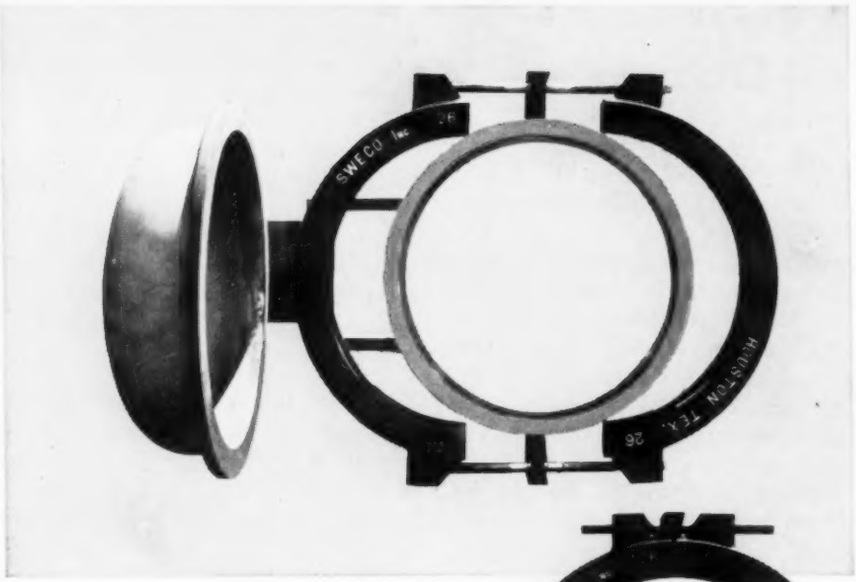

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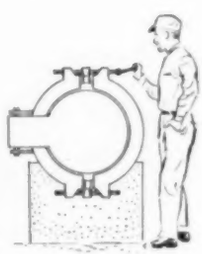

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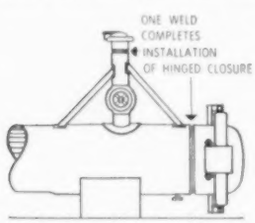

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At Wood River the Wabash system will receive deliveries from Cherokee Pipe Line which is connected to Continental and Cities Service refineries in Ponca City, Okla., and the D-X Sunray and Texas Co. refineries in Tulsa.

October Start Due on Shell's Louisiana Line

Shell Pipe Line Corporation has awarded contract to Houston Contracting Company for 62 miles of 20-inch crude line from the Nairn, La. area to the Norco refinery.

Shell plans to construct a line extending 100 miles from the Southwest Pass Delta area to Norco. Contract will be let soon on the south section of the line.

Houston Contracting Company will begin work on the Shell line in October and completion is expected in December.

Foothills Pipe Line, Ltd. Plans $80 Million LPG Line

Foothills Products Pipe Line, Ltd. has announced plans for an LPG line from Alberta to the Pacific Coast. Foothills has been formed by Canadian business men backed by Pembina Pipe Line, Ltd. and Mannix Co. Ltd.

The company has engineering studies of the $80 million project to determine the most suitable route. Included in the study was a gathering system to tie in liquid byproducts from present and future gas fields of the province.

Transco Expansion Plans Passed by FPC Examiner

Transcontinental Gas Pipe Line Corporation has received Federal Power Commission examiner approval for its $167 million expansion program.

Included in the construction proposal is 556 miles of main line loops, 38,500 compressor horsepower and about 345 miles of purchase laterals to connect new gas supplies in southern Louisiana, Texas and offshore Louisiana.

Contracts recently let by Transco, pending final approval, include 75 miles, 36-inch, loops in North Carolina and Virginia to be laid by J. P. Neill & Company, Inc.; Sharman, Allen, Gay & Taylor will construct 65 miles of 30 and 36-inch loops in Texas, Louisiana and Mississippi.

PROPOSED PIPE LINE CONSTRUCTION

Here in convenient summary form is Pipe Line Industry's listing of company, line size, length, service, location and project status.

U. S.

Chicago District Pipeline Company, 52 miles, 30-36 inch, gas, from Natural Gas' proposed line at Joliet to Chicago, $13 million, before FPC.

Coastal States Gas Producing Co., Corpus Christi, Texas, 45-mile, gas gathering system in Bee County, Texas to connect with Texas Eastern's main pipe line, $1 million, planned.

Coastal Transmission Corp., Houston, 574 miles, 22-24 inch, gas, from McAllen, Texas to Baton Rouge, La. connection of Houston, Texas Gas and Oil plus 414 miles of laterals, $55 million, contracts let on compressor stations to Gasoline Plant Construction Corp.

Colorado Interstate Gas Co., Colorado Springs, 734 miles, 24-30 inch, gas, from Texas & Okla. Panhandle to Kit Carson, Colo., to Beatrice, Neb., plus four compressor stations, $87 million, before FPC.

Conn-Mass Pipe Line, Inc., Orange, Conn., 88 miles, 8 inch, products, from Boston to Springfield, Mass., considered.

133 miles, 16-inch, products, from Linden, N. J. to Hartford, Conn., considered.

62.2 miles, 8-inch, products, from New Haven, Conn. to Springfield, Mass., considered.

38 miles, 6-inch, products, from Waltham, Mass. to Fitchburg, Mass., considered.

Consumers Power Co., 45 miles, gas, main line, from Woodbury station to Laingsburg Junction, Mich., planned.

126-miles, 26-inch, gas, main, Michigan-Indiana border to Plymouth, Mich., planned.

Deep Rock Gas Co., Oklahoma City, 120 miles, 6-inch, LPG, from Tioga, N. D., to Canadian border, planned.

Eastern Shore Natural Gas Company, Salisbury, Md., 124 miles, 6 and 8-inch, gas facilities on eastern shore areas of Delaware and Maryland, $3 million, contract let to Fulghum Contracting Company and Buchanan Pipe Line Construction Company.

El Paso Natural Gas Company, El Paso, 216 miles, 26 to 34-inch main line, 533 miles, 6-20-inch laterals, gas, 86,750 compressor hp; 126 miles, 30-inch main line, 266 miles, laterals, gas, 28,920 compressor hp in new and existing stations in Arizona, New Mexico and Texas, contracts let on 505 miles to R. H. Fulton & Co., McVean & Barlow, Inc., and Western Pipe Line, Inc.

511 miles, 34-inch, Twin Falls, Idaho to California border near Las Vegas, planned.

Emerald Pipe Line Corp., 195 miles, 6 inch, products, from Tucumcari, N. M., to Albuquerque, N. M., planned.

Equitable Gas Company, Pittsburgh, Penn., 11.7 miles of storage pipe line and other facilities, $2,091,430, authorized.

Everglades Pipe Line Company, Miami, Fla., 35 miles, 10-inch, products, Port Everglades to Miami International Airport, $2.5 million, planned.

Gillette Pipeline Co., Cheyenne, Wyo., 103 miles, crude, from Dead Horse Creek field to Casper, Wyo., planned.

Great Northern Railway, St. Paul, 400-600 miles, 12-20 inch, crude, from Williston Basin to St. Paul-Minneapolis and Duluth-Superior areas, considered.

Gulf Interstate Gas Co., Houston, 12.8 miles, 6 and 20 inch, gas, loop line in Louisiana, $730,000, authorized.

350 miles, 30-inch, and 55 miles, 24-inch, loop lines in Kentucky, Mississippi, Tennessee, and Louisiana, $50 million, contracts let to Houston Contracting Company and H. C. Price Company.

Gulf Pacific Pipe Line Company, 1,600 miles, 30-inch, gas, Louisiana to California border, considered.

Gulf Resources, New York, 125 miles, gas, gathering system, from Lopena area in Zapata County to a point in La Salle County, Texas, planned.

Harry Bass & Sons, Inc., Dallas, gas gathering lines, Pembina field, Alberta, $17 million, approved.

Humble Oil & Refining Co., 250 miles, 26 or 30 inch, gas and 116 miles, main gathering system, varying sizes, from southwest Texas to Houston, plus gas processing and cycling plant near Corpus Christi, $75 million, planned.

Iron Ranges Natural Gas Co., 115 miles, gas, from Itasca and St. Louis counties along route of Mesabi range from Grand Rapids to Aurora, Minn., $5 million, before FPC.

Katy and New York Central Railroads, 2500-mile, 10-12 inch, LPG, from Houston, Texas, to New York, considered.

Kerr-McGee Oil Industries, Inc., 24 miles, 4 inch, gas, to connect wells with its Breton Sound production island off the Louisiana coast, authorized.

Magna Pipeline Co., 40 miles, gas, underwater line from Anacortes, Wash., to Victoria, B. C., $6 million, planned.

Manufacturers Light and Heat Co., Pittsburgh, Penn., 13.8 miles, 10 and 12 inch, gas, facilities in Ohio and West Virginia, $757,300, authorized.

28 miles of 8, 12 and 26-inch line, gas, in Ohio and Penn., planned.

Michigan Gas Storage Co., Jackson, Mich., gas, facilities in central Michigan, $2 million, authorized.

Michigan Wisconsin Pipe Line Co., Detroit.

102 miles, 4- to 20-inch, gas lines to connect new gas supplies in Laverne field, Oklahoma, authorization for a part.

25.3 miles, 12-inch, lateral loop, in Wisconsin, before FPC.

20.5 miles, 24-inch, main line loop in Michigan, before FPC.

Midwestern Gas Transmission Co., Houston, 2067 miles, 3—24-inch, gas, from Emerson, Manitoba to Portland, Tenn., $111 million, before FPC.

Mookl Chemical & Gas Corp., Tulsa, and Missouri Transmission Corp., Springfield, Mo., 425 miles, 16-inch, gas, from Oklahoma City area to St. Louis, before FPC.

Natural Gas Pipe Line Co. of America, 416 miles, 36 inch, gas, loops at various points along existing line between Beatrice, Neb., and Joliet, Ill., $76.2 million, before FPC.

396 miles, 30-inch, gas, loops between company's terminus near Fritch, Texas and Joliet, Ill., $63 million, before FPC.

258 miles, 36-inch and 21 miles, 26-inch, gas, loops, between Fritch, Texas, and Beatrice, Neb.; 232 miles, 36-inch, loops, between Beatrice and Joliet, Ill. $87 million, contracts let to R. H. Fulton & Co., Williams Brothers, and Contracting and Material Company.

North Carolina Natural Gas Corp., 630 miles, 2-16 inch, from Transco's system near Mooresville across to southeastern North Carolina, authorized.

Northern Illinois Gas Company, 140 miles, 24-inch, gas, main line, East Dubuque to Des Plaines, Ill., planned.

Northern Natural Gas Co., Omaha, 167 miles, 20 inch, gas, from Farmington, Minn. to Duluth, Minn., and Superior, Wis., $12 million, before FPC.

42 miles, 10 inch, gas, from Rochester, Minn. to Winona and Goodview, Minn., $963,000, before FPC.

365 miles, gas, new facilities in Minn., Iowa, S. D., Neb., Wis., plus 1090 miles of branch line and station facilities, $65.7 million, authorization for a part. Gas facilities in Texas, Oklahoma and Kansas, $6 million, before FPC.

454 miles, main line loops and extensions, 6-30-inch, main line from St Cloud, Minn., to Grand Forks, N. Dak., also 1,490 miles of branch lines, 2-10-inch, and station additions totaling 32,000 horsepower, $86 million, planned.

27.6 miles, 30-inch, gas, loop; 18.3 miles north of Beaver station in Okla., 9.3 miles north of Sunray station in Texas, $3 million, authorized.

Northern Utilities Co., 35 miles, 16 inch, gas, in Fremont Natrona County, Wyo., area; 8 miles, 12 inch, around Casper; 6 miles, 8 inch, from Sand Draw gas field to Beaver Creek field; 12 miles, 6 inch, from Beaver Creek field to the system servicing the Riverton-Lander area, planned.

Ohio Fuel Gas Co., 51 miles, gas, main lines, in Belmont, Carroll, Cuyahoga, Fairfield, Logan, Lorain, Marion, Mus-

kingun, Stark and Wayne counties, Ohio, $2.2 million, authorized.

Natural gas storage field in Medina County, Ohio, 12 miles, 4½ to 20-inch, gas, $5 million, temporary FPC authorization.

Pacific Gas & Electric Co., 1300 miles, gas, from Alberta, Canada to Antioch, Calif., $380 million, planned.

Pacific Lighting Gas Supply Co., 128-mile, 34-inch, gas, main line from Topock, Ariz. to Newberry, Calif., planned.

Pacific Northwest Pipeline Corp., Salt Lake City, 235 miles gas, gathering lines in San Juan Basin, Garmesa, Piceance Creek, and Big Piney Fields, $13.5 million, planned.

65 miles, gas, sales laterals in Washington, $1.5 million, planned.

52 miles, 30-inch loop Big Piney, Wyoming, gathering system, $5 million, planned.

123-mile, 30-inch, gas, Spokane to Kingsgate, Wash., planned.

Pennsylvania Gas Co., Warren, Penn., 38 miles, 8 and 10 inch, gas, in Erie and Warren Counties, Penn., and Chautauqua County, N. Y., $2.6 million, authorized.

Piedmont Gas Co., Hickory, N. C., 78 miles, 2-8 inch, gas, from connection with Transcontinental Gas Pipe Line to serve customers in North Carolina, $2.6 million, authorized.

Phillips Petroleum Co., 25 miles, 6 to 20-inch, gas, South Eunice, New Mexico area, planned.

52 miles, 4 to 20-inch, gas, Gaines County, Texas, planned.

44-mile, 6-inch, products line, from Rocky pump stations to Amarillo, Texas, planned.

Plantation Pipe Line Company, 48-mile, 4-inch, products, between Bremen and LaGrange, Ga., $1 million planned.

Service Pipe Line Company, Casper, Wyo., 4,000 compressor hp at Herndon, Kans., 2,000 compressor hp at Scranton, Kans., and 2,000 compressor hp at LaGrange, Wyo.; additional 2,000 hp at Laton station, Rocks County, Kans., 2,200 additional hp at Elk Basin, Kirby, Owl Creek, and Lost Cabin stations, north of Casper, Wyo., planned.

Shell Pipe Line Corp., Houston, 100 miles, 18-20 inch, crude, Southwest Pass to Norco Refinery near New Orleans, $10 million, contract let to Houston Contracting Co. on 62 miles.

43 miles, 8-inch, crude, main, and 20 miles, crude gathering, Colorado City, Texas, to Borden-Garza County of West Texas, planned.

Southern Kansas Pipe Line Co., Inc., Arkansas City, Kansas, 200 miles, 6-10 inch, crude, southwestern Kansas to Arkansas City, Kansas, planned.

Southern Natural Gas Company, Birmingham, 136 miles, 24 and 26 inch; 215 miles, various diameter supply lines; 3,650 additional compressor horsepower to White Castle and Toca Stations; 8 miles, 20-inch loops; 660 hp Franklinton station, and 23 measuring stations. $40 million, contracts let to William Brothers, Western Pipe Line, Inc, and River Construction Corp. on 183 miles.

458 miles, 16-24-inch, loop lines, gas, between Gwinville, Miss., and Wrens, Ga.; 62 miles, 14-inch, loops, along Atlanta-Macon line; 53 miles, 6⅝ to 14-inch, loops, along various branch lines. 3,140 additional hp at Gallion and Elmore, Ala. and Wrens, Ga. 60 miles, 20-inch, loops, in Louisiana between Franklinton and White Castle and South of Toca. Lateral lines south of Gwinville and west to Cranfield field. 8,720 hp added at Franklinton, White Castle, Patterson and Brookhaven. $65 million. contracts let to River Construction Corp., H. C. Price, and Houston Contracting Co. on 333 miles.

Tennessee Gas Transmission Co., Houston, 264 miles loop lines in Tennessee, Kentucky, West Virginia and Pennsylvania, FPC Examiner authorization.

Compressor stations in Mississippi, Tennessee, New York, Pennsylvania and additions in Tennessee, Kentucky, Ohio and Pennsylvania, $129 million, temporary FPC Examiner authorization.

21 miles, 16-inch, 2 miles, 12¾-inch, gas, Louisiana coast, Vermillion, Blocks 46 and 64, $2.9 million, before FPC.

Texas Eastern-Penn-Jersey Transmission Corp., Shreveport, La., 65 miles, gas, from Delmont, Penn., to Lambertville, N. J., before FPC.

24,000 compressor hp additions to existing stations, $4.4 million, temporary FPC authorization.

4,000 horsepower to its Delmont, Penn., compressor station, five new compressor stations in Pennsylvania with total capacity of 67,000 hp, $11.2 million, authorized.

Texas Eastern Transmission Corp., Shreveport, La., 267 miles, 14-30 inch, gas, Louisiana, Mississippi, Pennsylvania and New Jersey, $50 million, before FPC.

96.5 miles, 30-inch, gas, between Kosciusko, Miss., and Uniontown, Penn.; 9.4 miles of supply laterals; a 10,250 hp compressor station, and 33,360 hp to existing compressor stations, $24.5 million, authorized.

141,780 additional horsepower in existing stations, a new 2,200 hp compressor station, in Louisiana, Mississippi, Pennsylvania, Ohio, Kentucky and Tennessee, authorized.

Texas Eastern Transmission Corporation and Wilcox Trend Gathering System, Inc., gas, compressor stations, $4 million, authorized.

Texas Gas Gathering Corp., Shreveport, 36.6 miles, gas, gathering system in Rodney Field, Jefferson County, Miss. and from North and South Locust Ridge, Lake St. John Field in Tensas and Concordia parishes, La., $855,413, before FPC.

Texas Gas Transmission Corporation, Owensboro, Ky., 92 miles, 30-inch, 19 miles, 26-inch, and 15 miles, small diameter, loop portions of system in Louisiana, Arkansas, Mississippi, Kentucky, Indiana and Illinois; additional horsepower at Pineville, La., Kenton, Tenn., Calvert City, Ky., Slaughters, Ky., Dillsboro, Ind., and Petersburg, Ind., totaling 9,040 hp. $20 million, before FPC.

Texas Illinois Gas Pipeline Company, Chicago, 16,000 additional hp to stations at Lufkin, and Marshall, Texas; Texarkana, Malvern, Searcy, and Biggers, Ark.; Jackson, Mo.; and Hammond, Ill., $3.9 million, before FPC.

Transcontinental Gas Pipe Line Corp., Houston, 204 miles, 36-inch, 107 miles, 30-inch, main line loops in 10 stations; 3 intermediate stations: North Carolina, Virginia, Pennsylvania; 2,500 additional hp at six compressor stations; 1.4 miles, 24-inch from Leidy storage Penn.; 29 miles, 30-inch, New Jersey; gathering lines, Louisiana, 119 miles; 10 meter stations; additions to West Cameron and High Island area, 35-miles, 16-inch, 5 miles, 10-inch, and three gathering meter stations; 45 miles, 16-inch, purchase laterals and 5 meter stations, Louisiana; 67 miles, 10, 12, 20-inch miscellaneous transmission purchase laterals in Texas and Louisiana, 3 meter stations; 51 miles, 36-inch and 1 mile 30-inch in New Jersey; 51 miles, 10 and 14-inch and 3 meter stations, southeast Louisiana (mainly offshore) $137.3 million FPC Examiner approval.

151 miles, 24-inch, 12 meter stations, southeast Louisiana, $14.5 million FPC Examiner approval.

2,500 additional hp at four compressor stations, St. Francisville, La.; Laurel, Miss.: Linden, Ala. and Wadley, Ala., $3 million FPC Examiner approval.

Wells, pipe lines, measuring equipment, stations at Leidy storage in Pennsylvania, $12.5 million FPC Examiner approval

Trans-Utah Pipeline, 16-inch, gas, main line from Uinta Basin to Salt Lake City, considered.

Transwestern Pipeline Company, Houston, 1,305 miles, 24- and 30-inch, gas, main line, from West Texas and Oklahoma-Texas Panhandle area to Topock, Ariz., $193 million, before FPC.

Trunkline Gas Company, Houston, 204 miles, 26-inch, gas, main line from Tuscola, Ill., to Michigan-Indiana border; 464 miles, 30-inch loops between Longville, La., and Tuscola and 45 miles, 24-inch, in Texas, 183 miles gathering, Louisiana, 3000 additional hp at Longville station, $81.5 million, before FPC.

Underground Storage & Exploration, Upper Darby, Penn., 394 miles, 12-inch LPG, from Moundsville, W. Va. to Newark, N. J., $9 million, approved.

95 miles, 6-8 inch, laterals to Mauch Chunk, Penn., and to Philadelphia, planned.

United Gas Pipe Line Co., Shreveport, La., 203 miles, 30-inch, gas, between New Orleans and Mobile, Ala., $33.7 million, authorized.

Wabash Pipe Line Company, 265-mile, 12-inch, products, Wood River, Ill., to East Chicago, contract let to Contracting and Material Company.

International

ACT Oils, Ltd., Montreal, 400 miles, crude, Dawson Creek, B. C., to Bella Coola, B. C., before B. C. government.

Alaska-Yukon Refiners and Distributors, Ltd., Edmonton, Alta., 150 miles, products, serving Alaska and Yukon territory, $3.5 million, planned.

Bituminous Oil Pipeline Co., Calgary, 250 miles, crude, from Athabasca tar sand plant in northeastern Alberta to Edmonton, approved.

British Petroleum Co., 60 miles, crude, from deep water tanker terminal at Milford Haven, U. K. to Llandarcy Refinery, $18 million, planned.

Burmah Oil Co., Ltd., 850 miles, crude, 20 inch, from Nahorkatiya to Calcutta, India, planned.

Consolidated Gathering Systems, Ltd., Calgary, 198 miles, crude, Sturgeon field to Edmonton, planned.

Development and Resources Corp., 70 miles, 8 inch, gas, from Agha Jari oil field to Ahwaz, Iran, planned.

Elburz Oil Corp., 1000 miles, crude, from Central Iran to Alexandretta, Turkey, $450 million, planned.

Entre Nazionali Idrocarburi, Rome, Italy, crude, from Qum field in Iran to the Mediterranean Sea, considered.

Federated Pipe Lines, Ltd., 125 miles, 10¾-inch, crude, main line, from Swan Hills area of Northern Alberta to Edmonton, approved.

Foothills Pipe Line, Ltd., 500 miles, 12 to 16-inch, LPG, from Alberta to Pacific Coast, $80 million, considered.

Hydrocarbons Pipeline, Ltd., Winnipeg, Manitoba, 880 miles, 6-8 inch, products, from Edmonton to Winnipeg, $35 million, partial authorization.

Independent Pipe Line Co., 2,019 miles, 34-36-inch, crude, Edmonton to Montreal, 23,000 pump horsepower, $395 million, before Borden Commission.

Interprovincial Pipe Line Company, 350-mile extension from Toronto to Montreal, looping line from Edmonton to Toronto, crude, $240 million, considered.

Mid-Continent Pipe Lines, Ltd., 1500-mile, 30-inch crude, Edmonton to Chicago, planned.

National Iranian Oil Co., 146 miles, 6 inch, crude, from Azna to Isfahan, Iran, $5 million, planned.

1000 miles, 38 inch, crude, from central Iran to the Turkish Mediterranean coast, considered.

Peace River Oil Pipe Line Co., Ltd., 70-mile, crude, Swan Hills to Iosegun Junction, approved.

Petroleos Mexicanos, 108 miles, 10 inch, gas, from Gral. Escobedo to Monclova to tie into Reynosa-Monterrey gas pipe line, $9 million, planned.

600 miles, 24 inch, gas, from Pemex City to Mexico City, $50 million, planned.

38 miles, 4 inch, products, from Mexico City to Toluca, $500,000 planned.

126 miles, 4, 6 and 8 inch, products, from Mexico City to Cuernavaca and Puebla, $2.5 million, planned.

Rotterdam-Rhine Pipeline Co., 185 miles, 28-inch, crude, from Rotterdam to Wesseling, Germany, preliminary work under way. Contracts let to Mannesmann-Seifert-Rohrbau, "Hoch-Tief," Strabag-Bau, Van Huttum en Blankevoort and Amsterdamse Ballast.

Sui Gas Transmission Co., Multan, Punjab, India, 145 miles, 8-inch, gas, from Sylhet to Dacca, East Pakistan, $9 million, considered.

130 miles, 16-inch, gas, main line, Multan to Lyallpur, planned.

Trans-Europe Pipe Line, 700 miles, 30 inch, main trunk, crude, from Mediterranean to northern Europe, considered.

Westcoast Transmission Company, Ltd., 174 miles, 30-inch, gas, Savanna Creek gas field, Alberta, to British Columbian border, $45 million, planned.

650 miles, crude, from Peace River area to Vancouver, $100 million, planned.

Williams-McWilliams Industries, Inc., New York, 441 miles, 6-inch, crude, Villa Montes, Bolivia to Villa Hayes, Paraguay, considered.

Yacimientos Petroliferos Fiscales, Buenos Aires, Argentina, 621 miles, 12-inch, products, Mendoza to San Lorenzo, Argentina, $19 million, planned.

281 miles, 12¾ inch, crude, Pichanal to San Miguel Tucuman to Techint, S. A., planned.

450 miles, 16-inch, crude, from Neuquen Province to Bahia Blanca, planned.

Sinclair Awards Contract To Trojan Construction Co.

Sinclair Pipe Line Company has awarded a contract to Trojan Construction Co. Inc. to take-up and recondition 140 miles of 12¾-inch and 140 miles of 8⅝-inch pipe from Teague to Huffman, Texas.

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18"	6' 3"x16"x⅝"	71#	56#	96,000#
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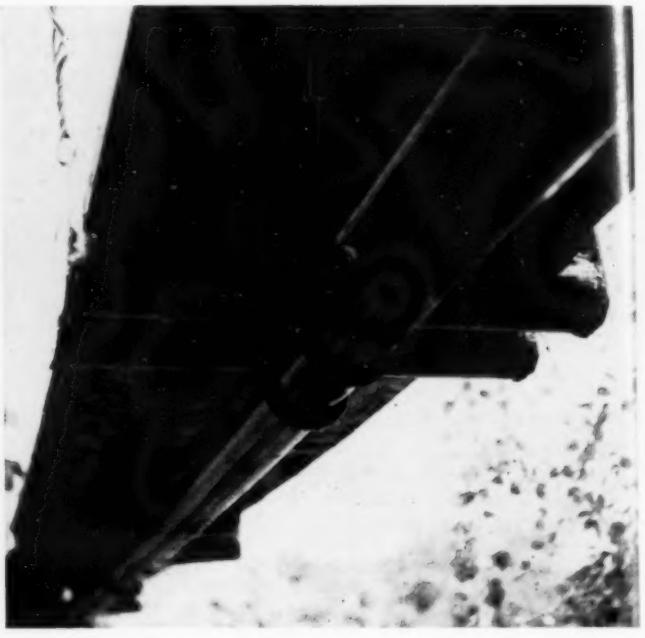
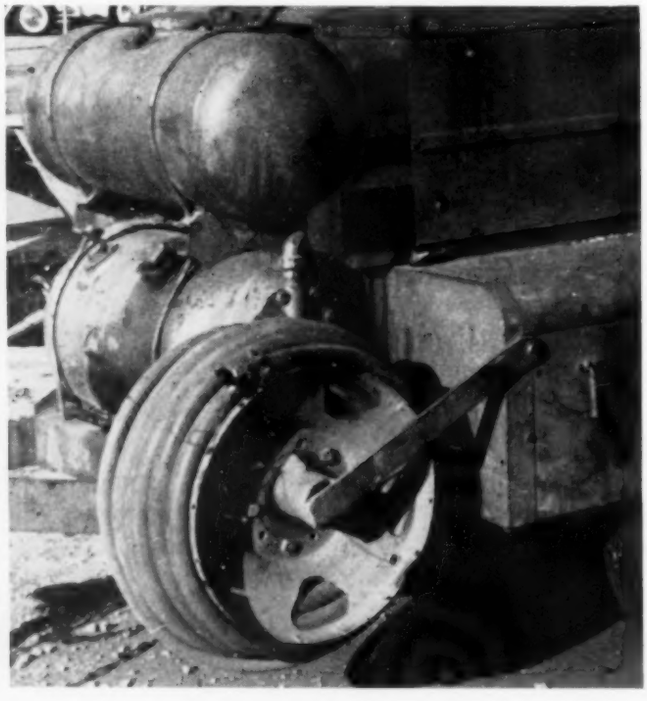


Pipe Line Used As Support to Make Short Foot Bridge

Where pipe line personnel find it necessary to cross short deep ravines that are hazardous and slippery in cold and wet weather, a foot bridge using the pipe line itself as the support will provide an easy crossing.

In the above illustrations, showing views of the top and beneath the bridge, the pipe line is a 2-inch line cased in 3-inch pipe, which is used as the support. Planks are held in place by small lateral pipes tied to the casing with "U" bolts. Small pieces of plate welded on the ends of the lateral supports prevent the plank from moving sideways and hold the tie cables to the main guardrail.

All material was prefabricated in a shop and assembled at the location in a short time. The deck was painted with non-skid paint for added safety.



Discarded Automobile Wheels Make Compressor Hose Spool

A simple spool for accommodating the air hose of a trailer type compressor can be made of two small diameter automobile wheels and attached to the hitch frame of the compressor as shown above.

The inside half of the tire holding rim is cut away on two discarded automobile wheels. The wheels are butted together with the inside of one wheel against the inside of the other wheel, with bolts through the hub holes holding the wheels together.

One end of a short piece of 2½-inch diameter pipe is welded to the hitch frame to serve as a hollow axle or shaft for the spool (wheels).

A flat piece of steel is welded over the end of the axle shaft and the other end is bolted to the side of the metal tool box to give needed rigidity.

Locating the hose spool, as shown, does not interfere in any way with the operation or maneuverability of the air compressor.

Improvised Lock Prevents Tampering With Plug Valves

Here's a way to discourage and prevent tampering with wrench operated plug valves. All that is required is a pipe collar large enough in diameter to slip over the wrench end of the taper plug, plus a circular steel disc to weld over one end of the pipe collar and a few links of chain.

The steel disc is welded to one end of the pipe collar to form a cup. One end of a three link chain is welded to the disc at about its center and the other end (third link) is welded to the outer edge of one of the valve flanges. About half of a single link is welded to the disc on the end of the collar, but pointing in the opposite direction to form an eye for the loop of a padlock. One end of two links is welded to the opposite valve flange.

The loop of a padlock joins the single eye and the free end of the two links together, as shown, thus holding the cover over the wrench end of the taper plug.

Homemade Recorder Shelter Aids Operator; Protects Meter

A homemade flow recorder shelter constructed from a piece of 20-inch pipe provides weather-proof protection for the enclosed meter. The transparent door allows an operator to take readings without opening the door.

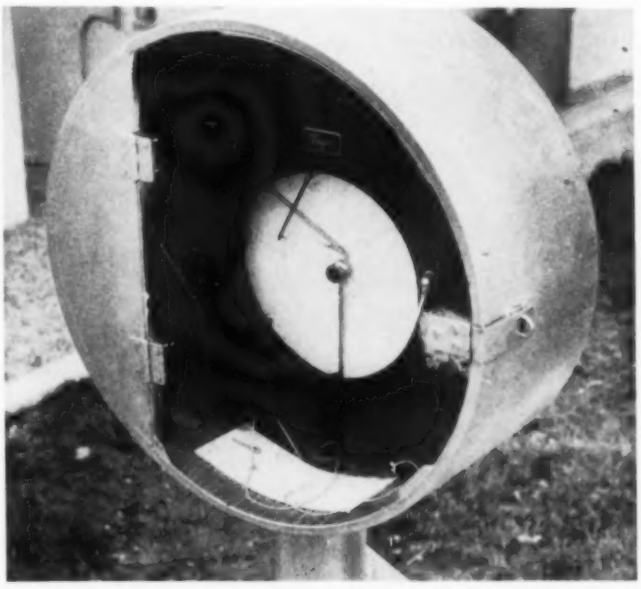
The section of pipe is attached to a small diameter pipe, and a steel cover is welded on the back. The transparent door does not have to be unlocked except when it is necessary to change paper on the recording meter.

Pole-Step Ladder Eases Pedestrian Fence Crossing

A practical fence crossing aid for the pedestrian pipe line inspector is a pole and step arrangement, fabricated from three pieces of scrap 2-inch diameter pipe and a piece of flat steel welded to the top of the 16-inch horizontal piece of pipe to form a step.

Post holes dug just outside the fence wires and filled with concrete around the outside of the bottom ends of the pole step hold it rigidly in place with one end of the step projecting inside the fence wires.

By painting the top of the pole step a distinct color, it also serves as a pipe line course marker.



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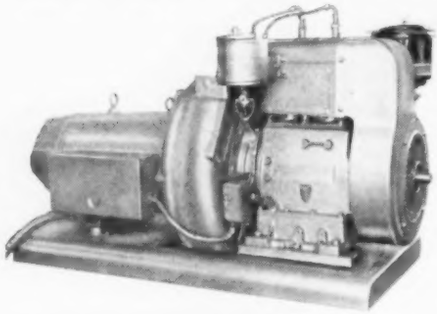

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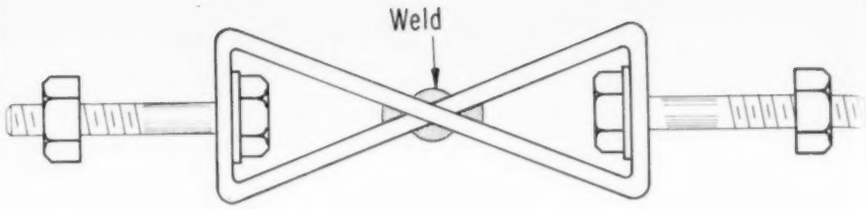


Make Swivel Buckle From Flat Steel

Many pipe line field stations are isolated from large or small supply houses. Emergencies often arise which require a certain piece of material in a hurry. If there is a need for a swivel buckle in such an emergency, one can be fabricated quickly and easily by using some flat steel and two bolts complete with washers and nuts, as shown in the sketch.

Extra Rung Below Bumper Protects Passenger Cars

Where truck bumpers do not match with passenger car bumpers, there is apt to be a lot of damage when contact is made. Also, it is impossible for a truck to push a car when the bumpers are high. Chastain & Pebley, contractors of McAllen, Texas, place an extra rung below the bumpers on their trucks and put on worn pipe protectors to protect the passenger car bumpers. It is a simple rig and makes a neat appearance for the front of the truck.

Use One Padlock to Secure Four Doors

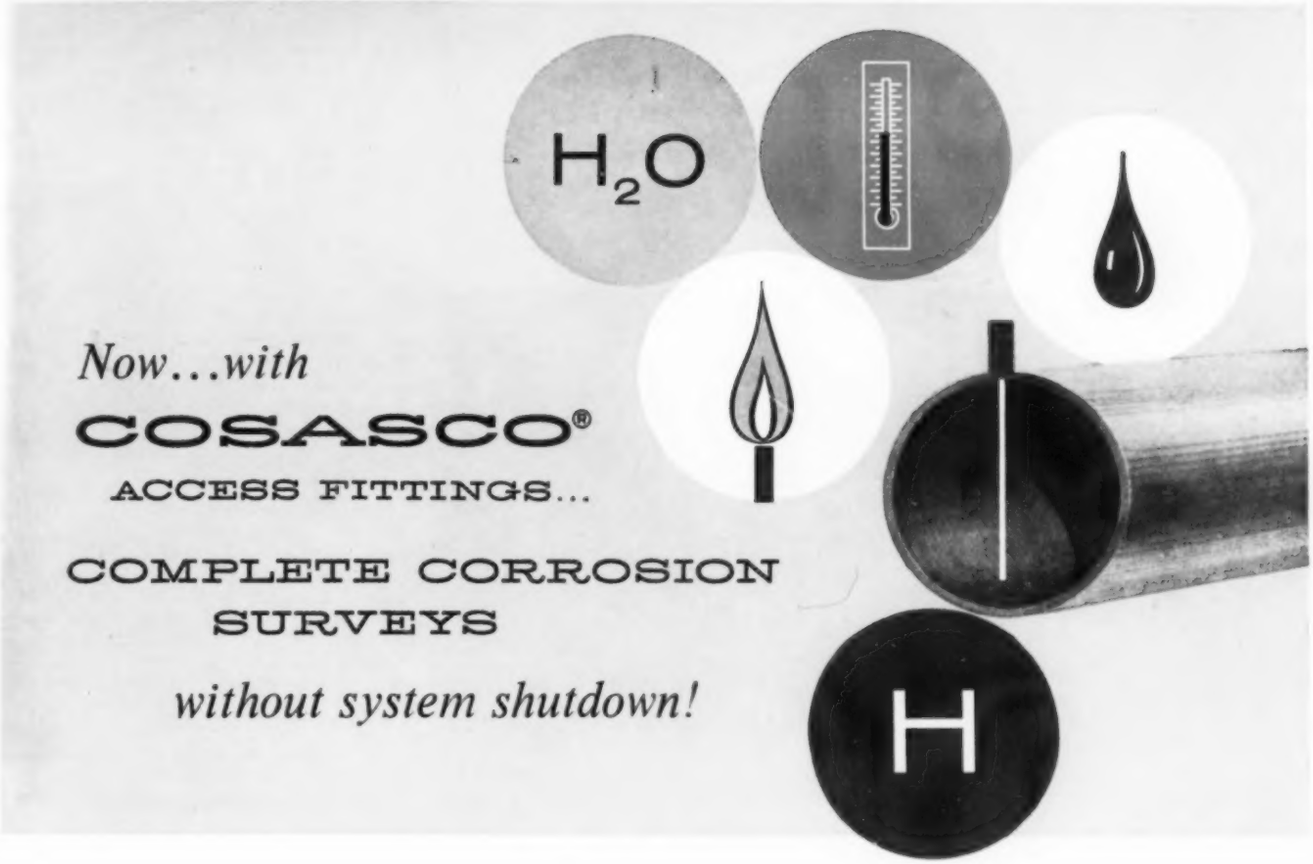
One company mechanic fixed his tool box so that the snapping of one lock would effectively lock all sections of the tool box. The lock was made by running a tee-shaped bar through the handles of the front doors of the tool box and then slipping the eye, in the end, over a hasp and snapping the lock.

With the tool box in this shape, he can take off the lock and slip out the tee-shaped bar in a matter of moments, and all tools are quickly available. Yet, they are stored safely when the tool box is locked.

Sump Pit Level Indicator Made From Old Broom Stick

Using an old broom stick or shovel handle, a visual sump pit level indicator can be made. Place the stick into the top of small mouth sample can inside the sump as a float. Make a small guide hole in sump cover to keep the indicator from drifting too much.

After calibrating the stick to indicate the desired degree of fullness or emptiness, paint "safe" portion of stick green, and "one-half full" portion yellow. "Pump out" portion should be wrapped with red reflective tape making it visible at night.



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CORROSION COUPON SURVEY. Enables the Corrosion Engineer to determine if corrosion is taking place. Grade 303 stainless steel coupon holder is installed through regular Cosasco Access Fitting body . . . can be easily inserted or withdrawn under pressure at any time. Holders are made in 3 categories adaptable to various line sizes and survey techniques. Corrosion coupons—available in standard lengths of 3″, 6″, and 8″, in any type of steel or rare metal—may be fully insulated from holders . . . remain unaffected by external soil conditions.

WATER SAMPLING SURVEY. Takes sample of line fluid for analysis. Special Cosasco water sampling plug with extension nipple and fluid catch attachment of S. S. 303 is inserted in Access Fitting body through main valve. An upper S. S. assembly consisting of a horizontal and vertical run, each with ½″ valve, is installed on the main valve. This permits taking a sample under full pressure and normal operating conditions to determine causes of corrosion.

THERMOCOUPLE SURVEY. Tells operator what part temperature is playing in corrosion problem. Cosasco thermocouple plug attachment (S. S. 303) is inserted in Access Fitting body and main valve is removed. Iron constantin wire is then pushed through gage carrier plug into position in the line. Thermocouple can be removed at will or hooked up to chart recorder for continuing temperature check.

ATOMIC HYDROGEN SURVEY. Discloses whether free atomic hydrogen is causing internal blistering. Cosasco hydrogen probe is installed through body of Access Fitting . . . can be easily withdrawn while vessel or line is on stream. Ball-check safety device protects against blowout or damage to gage should lower end of probe be damaged by excessive hydrogen in line fluid. Probe detects presence of free atomic hydrogen . . . gages rate of hydrogen diffusion.

RATE-OF-CORROSION SURVEY. Gives rate-of-corrosion reading electronically. Cosasco Corrosometer* Probe is installed under pressure through Access Fitting . . . quickly gives corrosion reading in increments of microinches without removing specimens or interfering with operations. Readings can be made in as little as 30 seconds without withdrawing the probe.

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What's Happening

among MEN in the INDUSTRY

Chairmen of Gas Industry's Piping Code Committee

John H. Carson (left) chairman of ASA Subcommittee 8 and vice president of the East Ohio Gas Company, discusses the ASA pressure piping code with his vice chairmen. Vice chairmen include (left to right) Walter H. Davidson, Transcontinental Gas Pipe Line Corporation; John F. Eichelmann, El Paso Natural Gas Company, and B. C. White, Warren Petroleum International Corporation. The industry's code committee for Section 8 of the American Standard Code for Pressure Piping, ASA B31, meeting was attended by more than 80 members and guests from transmission, distribution, construction and steel companies.

John D. Sturtevant

S. G. Loy

Humble Pipe Line Company announces several district appointments and a new controller of the company.

S. G. Loy, who has been with Humble nearly 39 years, retires as controller and will be succeeded by **John D. Sturtevant.** Loy started with the company as a clerk in 1919. He was named controller in 1941 and has been a director of the company for 10 years.

Sturtevant joined Humble in 1946 and was promoted to assistant controller in 1957. He is a member of the API Transportation Advisory Committee and the Oil Pipeline Advisory Committee on Valuation of the Interstate Commerce Commission.

Other appointments include **Harvey Cecil Evans** named division oil movement superintendent and **Frank Osro Perry**, division maintenance and construction superintendent, Houston. **Russell Leroy Baird Sr.** was made superintendent of the Tomball district and **Edward Isador Walker** was appointed superintendent of the Webster district.

Robert C. Wiles, assistant comptroller of **Service Pipe Line Co.**, has been appointed assistant comptroller of the **American Oil Company.** American Oil and Service are subsidiaries of Standard Oil Co. (Ind.). Wiles joined a Standard subsidiary, American Oil Pipe Line Co., in 1942.

H. M. Karr has been appointed to the newly created position of manager-technology in **Shell Pipe Line Corporation's** head office in Houston. Karr, formerly assistant manager of **Shell Oil Company's** Manufacturing Organization Engineering department, will coordinate and supervise activities of the engineering department and the Technical Services department. Karr joined Shell in 1938 and has held Engineering positions in San Francisco, New York and Houston.

Ed Parkes, president of United Gas Pipe Line Company and Union Producing Company, has been elected president of **United Gas Corporation.** Parkes, formerly executive vice president of the corporation, succeeds **N. C. McGowen**, who will remain as chairman of the board. The latter had been president since 1944.

Ed Parkes

Parkes has been with the firm for 30 years. He became assistant general superintendent of pipe lines at Shreveport and in 1937 he was made general superintendent. He was named a vice president of the pipe line company in 1947 and in 1955 was elected president of the United Gas Pipe Line Company and Union Producing Company, and a director and executive vice president of United Gas Corporation.

D. Robert Croft of **Transcontinental Gas Pipe Line Corporation** has been named chairman of a session on pipe line materials at the 1958 Petroleum Mechanical Engineering Conference in Denver, Sept. 21-24. Croft is in charge of Transco's engineering and operations research. He has been with the company since 1948.

Dr. Henry L. Purdy of Vancouver was elected 1958 president of the **Canadian Gas Association** at its 51st annual meeting in Murray Bay, Quebec. Purdy succeeds **H. C. Darroch** as head of the association which serves as co-ordinating body for the county's gas industry.

Dr. Henry L. Purdy

Purdy is executive vice president of **B. C. Electric Co., Ltd.** and is in charge of Gas, Transportation, Industrial Relations and Sales divisions.

Reinhard M. Meyer has retired as chief accountant for **Sinclair Pipe Line Company** after 39 years of service with the company. **John L. Roberts**, assistant chief accountant, succeeds Meyer.

Cities Service Gas Company announces the retirement of **R. T. Wells**, director and manager of engineering and research. Wells, who had been with the company for 42 years, was active in engineering planning when Cities Service constructed 627 miles of interstate pipe line. He joined the company in 1916 as chief civil engineer, became chief engineer in 1939 and in 1953 assumed his present position.

Transwestern Pipeline Company announces the election of **Mills Cox** as president of the company. Cox succeeds **John**

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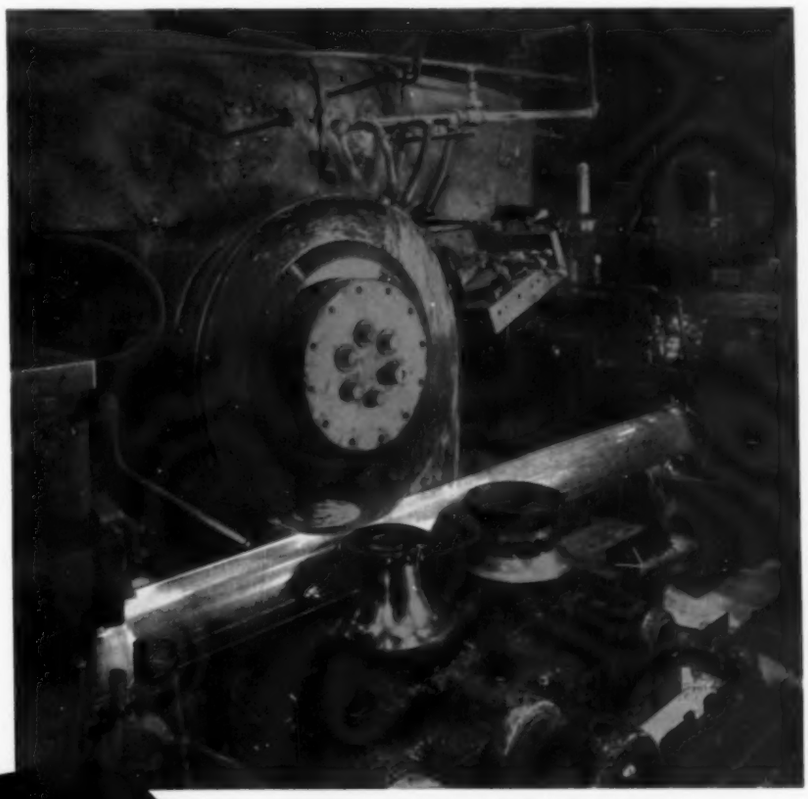
	.156"	7.25
	.188"	8.64
	.219"	10.00
	.237"	10.79
6⅝	.134"	9.29
	.156"	10.78
	.188"	12.89
	.219"	14.97
	.250"	17.02
	.280"	18.97



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R. **McMillian,** who has served as president and chairman of the board. He will continue as a board member. Cox had been executive vice president and in addition to being named president he will be chief executive officer.

Tennessee Gas Transmission Company announces the appointment of **Stephen D. Bechtel, Jr., as a** director of the company.

S. D. Bechtel

Bechtel is the executive vice president and director of Bechtel Corporation of San Francisco. He is also president and director of International Bechtel, Inc., and board chairman of Canadian Bechtel Ltd. He also serves as director of the Crocker-Angelo National Bank and of the Industrial Indemnity Co.

Phillips Petroleum Company's Supply and Transportation department has announced several appointments. **Charles M. Kittrell** has been transferred to New York City as manager of the newly established office of the department. **C. M. McCormick** is the new assistant to the manager of Supply division, and **L. A. Whitehair,** formerly administrative assistant to the manager of the Pipe Line division, has been appointed industrial relations director, replacing McCormick.

Kittrell, who joined Phillips in 1950, had been administrative assistant to the manager of the department. McCormick has been with the company since 1936 and has been in the Supply and Transportation department since 1952. Whitehair started with Phillips in 1929 and since has occupied various positions in the **Phillips Pipe Line Company.**

P. H. Yolland of **Humble Pipe Line Company** and **Mrs. Julie Wheeler** have been appointed to the Oil Information Committee. Yolland, Southern division superintendent of Humble, was named vice chairman of this area, and Wheeler is chairman of the area women's committee. Yolland will assist **Shell Oil Company's R. E. Dobyns** in directing the O.I.C. program in this 18 county area. Wheeler had been women's committee chairman in Corpus Christi with the **Champlin Oil & Refining Co.**

P. H. Yolland

Cities Service Gas Company's board of directors announces the re-election of **W. Alton Jones** as chairman, and **Burl S. Watson** as president.

Others re-elected include vice presidents, **A. P. Frame, Charles S. Mitchell,** and **George H. Hill, Jr.;** and **Erle G. Christian,** secretary. **J. F. Nelson,** who has been with the company since 1929, was elected treasurer. He will succeed **H. J. McCusker,** who recently retired. Nelson is also a director and officer of several Cities Service subsidiaries.

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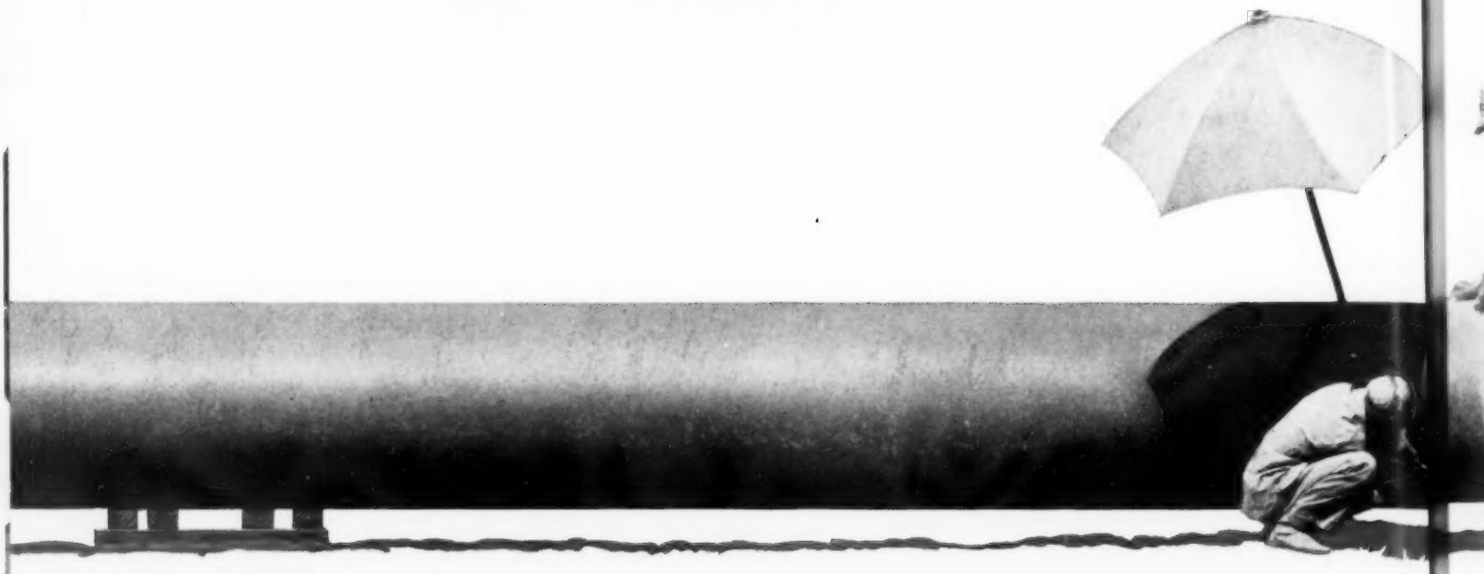

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ELECTRIC RESISTANCE-WELD	5 (nom) to 16	Standard & Extra Strong	to 60-ft	API 5L, Grades A & B API 5LX, Grades X42 & X46
CONTINUOUS BUTT-WELD	½ to 4 (nom)	Standard & Extra Strong	21-ft, ±1-in. ③	API 5L, ASTM 120; ASTM 53
COMPRESSOR STATION PIPE	in diameters, thicknesses, and lengths as required; fabricated from as-rolled, high-strength Mayari R steel; made in accordance with Sec. 8 of ASA B 31. 21.8—1955.			

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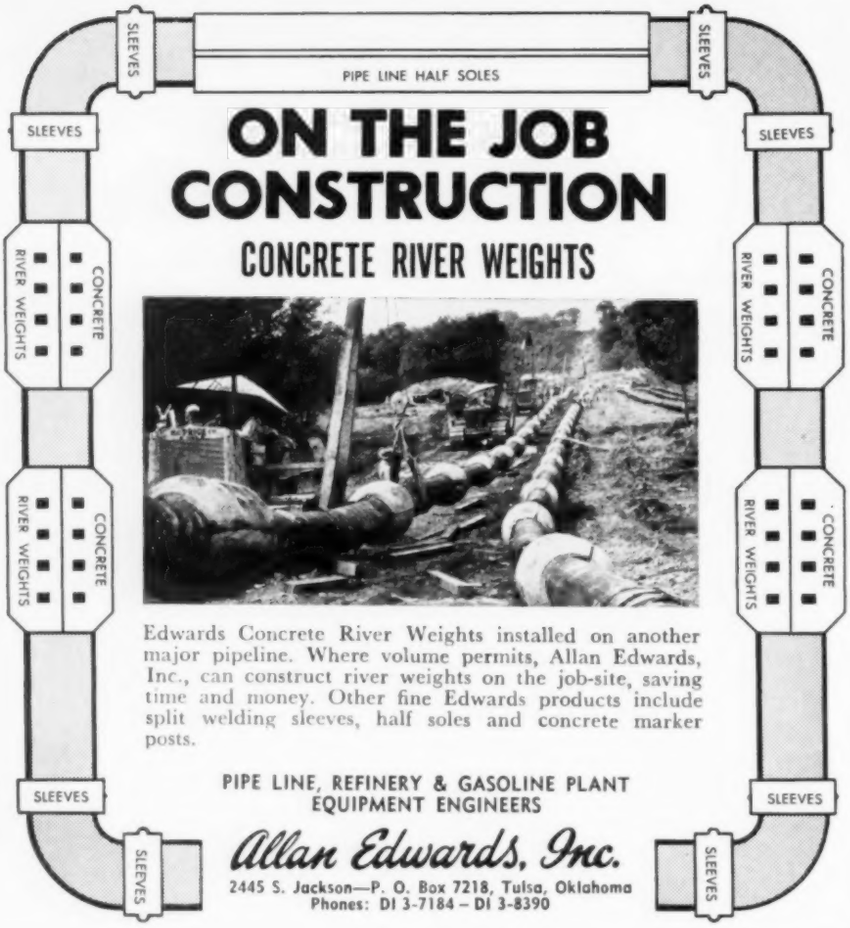

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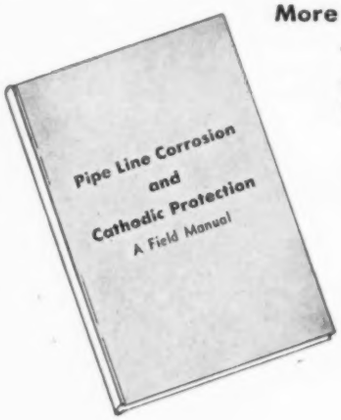
"... a most practical on-the-job manual for men concerned with pipe line corrosion. We are ordering copies for each of our district engineers."



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WHO'S MEETING WHERE

August

North Dakota Oil and Gas Association, Grand Pacific Hotel, Bismarck, N. D., August 18-19.

American Institute of Electrical Engineers, Sacramento, Aug. 19-22.

Appalachian Gas Measurement Short Course, University of West Virginia, Morgantown, W. Va., Aug. 25-27.

September

Pacific Coast Gas Association, Multnomah Hotel, Portland, Oregon, Sept. 2-4.

New Jersey Gas Association, Spring Lake, New Jersey, Sept. 5.

National Petroleum Association, 56th annual meeting, Traymore Hotel, Atlantic City, N. J., Sept. 10-12.

Instrument Society of America, 13th Annual Instrument Automation Conference and Exhibit, Philadelphia, Sept. 14-19.

Independent Natural Gas Association of America, annual membership meeting, Roosevelt Hotel, New Orleans, Sept. 15-16.

American Institute of Electrical Engineers, conference of petroleum industry, Baker Hotel, Dallas, Sept. 15-17.

Southeastern Gas Association, Sir Walter Hotel, Raleigh, N. C., Sept. 17-19.

Natural Gasoline Association of America, Rocky Mountain Regional meeting, Gladstone Hotel, Casper, Wyo., Sept. 18.

ASME, Petroleum division, mechanical engineering conference, Cosmopolitan Hotel, Denver, Sept. 21-24.

Seventh International Gas Conference, Rome, Italy, Sept. 22-25.

ASME, power conference, Hotel Statler, Boston, Sept. 28-Oct. 1.

October

NACE, Northeast Regional Conference, Hotel Somerset, Boston, Oct. 5-8.

California Natural Gasoline Association, 23rd annual fall meeting, Huntington-Sheraton Hotel, Pasadena, Calif., Oct. 9-10.

OIL PROGRESS WEEK, Oct. 12-18.

American Gas Association, annual convention, Atlantic City, N. J., Oct. 13-15.

National Electronics Conference, Hotel Sherman, Chicago, Oct. 13-15.

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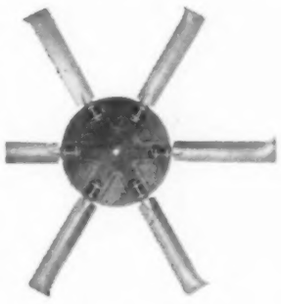

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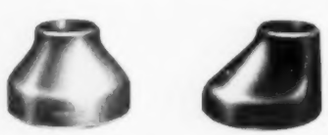

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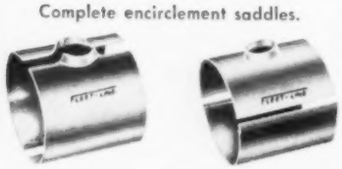

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What's Happening among SERVICE and SUPPLY MEN

General Electric Holds "Operation Upturn" Program

General Electric Communication Products department, in an effort to accelerate the upswing in business, has advanced an "Operation Upturn" program. L. W. Goostree, center, is chairman of the program. Others working on the campaign are, standing, left to right, R. E. Norem, B. White, R. P. Gifford, and G. H. Floyd. Seated are Harrison VanAken, department general manager, Goostree, and B. E. Saterlee.

Allis-Chalmers Completes New Seven Story Office Building

Allis-Chalmers recently erected a new, seven story office building directly across from the main office in West Allis, Wis. Departments which will be located in the new offices include Comptroller's division, Industrial and Community Relations division, Public Relations division, and Allis-Chalmers International.

The building has over 110,000 square feet of floor space and more than 800 employes. A main meeting room on the first floor will hold 500 people and a 130 foot enclosed bridge spans 70th street to connect with the main office.

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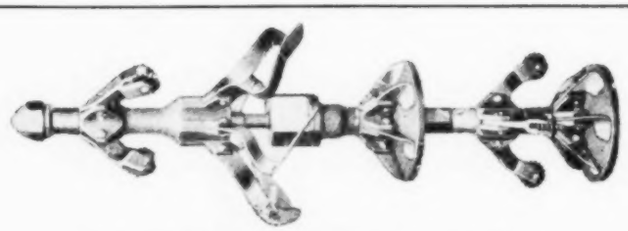
Hamer manufactures line blinds, gate and plug valves for petroleum, chemical and other industries. Barber Machinery

Go-Devil



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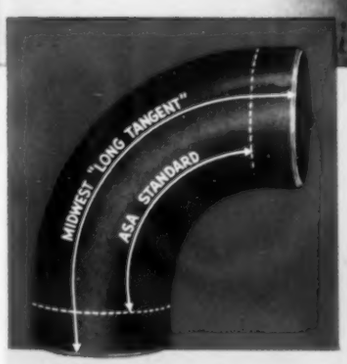

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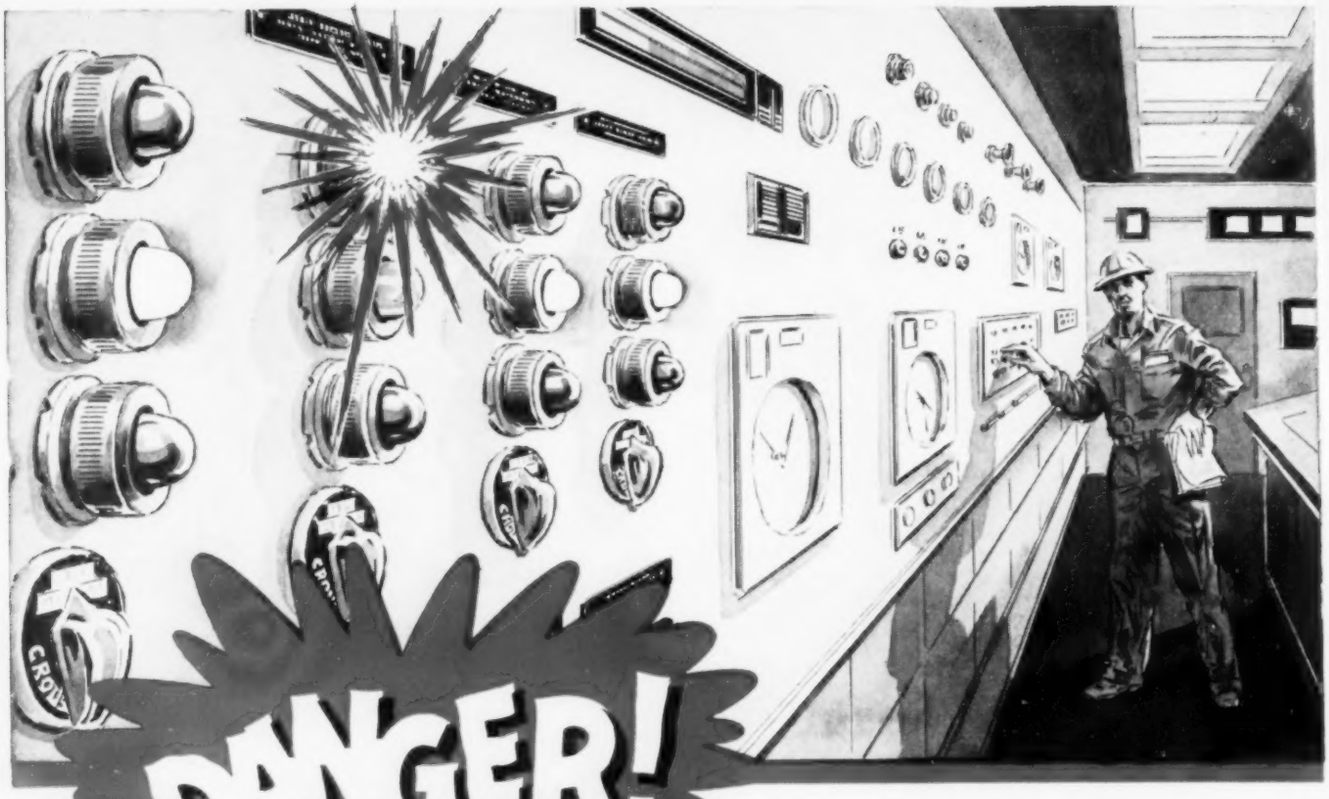
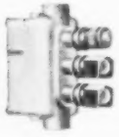


. . . instantly signaled by Crouse-Hinds *Visularms*®

Condulet Visularms

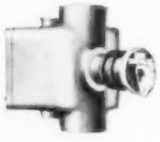
Condulet Horns, Bells & Sirens

Condulet Pilot Lights



Condulet Pushbutton Stations

Condulet Instrument Housings



Condulet Selector Switches

*Dust-ignition-proof.

In oil refineries, chemical plants, synthetic rubber plants — wherever constant watch of processing is necessary — Crouse-Hinds Condulet® *Visularms* provide visual indication of process conditions, and instant control of manufacturing equipment.

By means of pilot lights (and bell, horn or siren signals where desired) *Visularm* indicates normal or abnormal temperature, liquid level, pressure, or other conditions which can be electrically coupled to the circuit.

Explosion-proof or dust-tight and weather-resistant construction* assures maximum safety in hazardous locations. Compact designs minimize space required on control or panel boards . . . are easy to install.

A Visularm system delivers substantial savings by eliminating the necessity for buying individual components . . . housing them . . . and wiring your own system completely.

Two- or three-light styles may be mounted either vertically or horizontally. For audio warning, any number of *Visularms* may be used to operate a single horn, bell or siren.

Visularms are just one of hundreds of items in process control board equipment offered by Crouse-Hinds. Only a few are shown at left. For full information on the complete line, call your nearest Crouse-Hinds distributor, or write . . .

A NATIONWIDE DISTRIBUTION exclusively through ELECTRICAL DISTRIBUTORS

CROUSE-HINDS COMPANY

Main Office and Factory: Syracuse, N. Y.
Crouse-Hinds Company of Canada, Ltd.: Toronto, Ont.

Offices: Baton Rouge Birmingham Boston Buffalo Chicago Cincinnati Cleveland Corpus Christi Dallas Denver Detroit Houston Indianapolis Kansas City Los Angeles Milwaukee New Orleans New York Philadelphia Pittsburgh Portland, Ore. Salt Lake City St. Louis St. Paul San Francisco Seattle Tulsa Washington RESIDENT REPRESENTATIVES: Albany Atlanta Baltimore Charlotte Chattanooga Jacksonville Reading, Pa. Richmond, Va. Shreveport

as organized in 1939 and manufactures oil well drilling equipment, pressure vessels, mining and excavating equipment.

W. W. Blauvelt

Carrol G. Turk

Thew Shovel Company Announces Two Appointments

The Thew Shovel Company announces the appointment of W. W. Blauvelt as controller and Carrol G. Turk as service manager.

Blauvelt has been director of business planning and control since 1957. Prior to his association with Thew, he had been vice president and general manager of Byers Machine, Inc. Previously he had been with Mergenthaler Linotype Co. for 14 years.

Turk moves up from assistant to director of parts and service and will be responsible for all service activities on the Lorain line of power shovels and cranes and the Thew Moto-Loader. He will also continue as technical manager parts and service division.

Clyde Barbour Forms Engineering Company

Clyde Barbour has recently formed The Barbour Engineering Company for the purpose of constructing main line pumping stations, and their connected facilities, as well as field gathering systems. His company is also preparing for the industry a fully-automatic system by which any oil or gas producing section can be fully automated from wellhead through separators, tank batteries and into main line, completely unattended.

Clyde Barbour

Paul D. Moon Appointed Sales Promotion Manager

Paul D. Moon has been appointed new manager of sales promotion at Broderick & Bascom Rope Co.

He joined Broderick & Bascom in 1954 as district representative in the territory of Texas, Oklahoma and Kansas. Moon has 17 years experience in construction, oilfield, logging and industrial market sales. He became export manager of the company in 1956, and in his new position he will be in charge of advertising and sales promotion for Yellow Strand products in all markets.

Paul D. Moon

George T. Born, with the company

Pipelines! Hallmac has engineered and built pipelines under all climates, conditions and circumstances — on schedule! When you talk pipelines, talk to J. W. (Bill) Hall, President, Hallmac Construction Company, 3701 Buffalo Drive, Houston 19, Texas

since 1914, has been named product manager of American Logging Tool Corporation and Rixford Tool Division, a subsidiary of Broderick.

Joy Manufacturing Company Names Cartwright Vice President

Joy Manufacturing Company announces the election of John P. Cartwright as vice president and general manager of the Industrial division.

J. Y. Richards has been appointed to fill Cartwright's vacated spot as sales manager of the Industrial division. Cartwright has been with the company since 1950 and was promoted to sales manager in 1956.

Richards previously had been Chicago district sales manager and has been affiliated with the company since 1946.

W. F. Senkus Joins De Laval Headquarters Sales Office

De Laval Steam Turbine Company announces the transfer of W. F. Senkus from the Chicago district sales office to the headquarters Turbine Sales department in Trenton.

W. F. Senkus

In his new position Senkus will assist field sales offices in the promotion and sales of turbine and generators. Senkus has been associated with De Laval since 1949. Previously he served with the Elliott Company.

United States Steel Corp. Names Bay E. Estes, Jr., Vice President

Bay E. Estes, Jr., has been named vice president-marketing of the United States Steel Corporation. Other promotions announced includes S. D. Flinn as assistant to the president of Steel Supply division and Frank L. Johnstone as comptroller of the Steel Supply division.

Estes, who has been with the organization since 1939, will have supervision of the Advertising, Commercial Research, Product and Market Development divisions as well as administrative services of the Commercial department.

Flinn has been comptroller of the Supply division since 1951 and in recent months he also has been responsible for coordinating activities to integrate the former Gerrard Steel Strapping division with the Supply division.

Johnstone, who has been with the company for 12 years, became assistant comptroller in 1951.

ONLY the application-engineered

DATAGAGE*

REMOTE MEASUREMENT AND CONTROL SYSTEM

offers these exclusive advantages

NEW ACCURACY
- Only digital system with 1/16" accuracy independent of product gravity.
- Only system satisfactory for use in FLOATING ROOF TANKS.
- Only system to give reliable readings during blending turbulence.

NEW RELIABILITY
- Only system with POWER FLOAT (moving mechanical surface finder) which checks itself automatically.
- Transistors are used instead of short-lived vacuum tubes.
- A true digital system with unlimited-distance, error-safe telemetering.

NEW FLEXIBILITY
- Single dial control for both level and temperature measurement.
- 100 reading point capacity; applicable for alarm devices, valve and pump controls, remote transmission for data processing.
- Application-engineered approach gives you assured performance.

*Trademark registration applied for

Write for complete information, specify Bulletin M-601.

TEXAS INSTRUMENTS
INCORPORATED
INDUSTRIAL INSTRUMENTATION DIVISION
3609 BUFFALO SPEEDWAY • HOUSTON 6, TEXAS • CABLE: HOULAB

147

D. L. Gallogly

James R. Craine

Donald T. Koch

William Brafford

Cooper-Bessemer Announces Several New Appointments

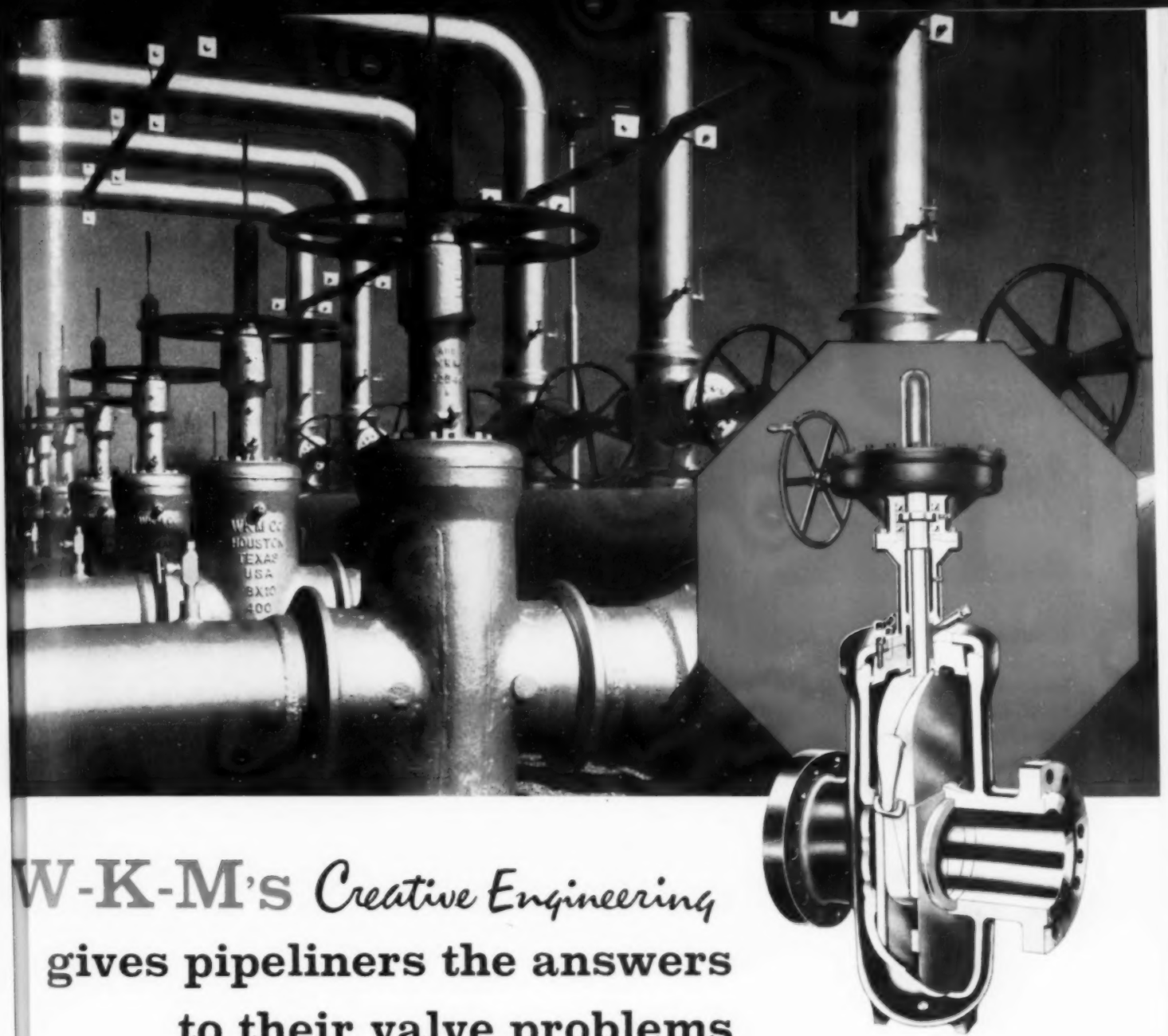
Cooper-Bessemer announces the promotion of several personnel in the Engineering and Sales departments. D. L. Gallogly has been elevated to the position of chief engineer, assuming responsibility for the supervision of all engineering departments.

Frank L. Friedli

William Brafford has been named field engineer to the Chicago district office. The new branch manager of Cooper's East Central district is James R. Craine, and Donald T. Koch is the new sales engineer of that district. Frank L. Friedli was promoted to the position of assistant sales manager, special projects.

Friedli will be directly responsible for the sales of automatic controls to the oil, gas, pipe line and power industries. Gal-

For more data on advertised products, use Readers' Service Cards, last page.



W-K-M's *Creative Engineering* gives pipeliners the answers to their valve problems

TYPICAL!

W-K-M's creative engineering process begins with your problems: design, production and field service are based on your needs. That's why W-K-M's ASA Gate Valves set the standards on pipelines throughout the world.

No other valve can give you tight seal upstream and downstream, *plus* the positive control of gate and segment afforded by W-K-M's exclusive gate centralizer.

No other valve gives you the same economical maintenance, the same long life combined with "on-the-line" overhaul.

For complete dependability and long-range economy, specify W-K-M ASA Gate Valves—they're the answer to all your pipeline valve problems.

This W-K-M ASA Gate Valve is typical of W-K-M's superior design, painstaking production, and thorough testing.

Features include: Through-conduit; pressure seal bonnet; parallel expanding gates; exclusive gate-centralizing mechanism; enclosed packing box; super-finished stem; seat lubrication.

Design assures: freedom from destructive turbulence . . . no surge operation . . . free passage for pigs or scrapers . . . on-the-line overhaul.

WRITE FOR CATALOG 300

W-K-M

DIVISION OF ACF INDUSTRIES INCORPORATED

P. O. BOX 2117, HOUSTON, TEXAS

5809

Oakite ECP...

Do your pipelines suffer from hardening of the arteries?

Pipelines lined with scale and sludge act just like hardened arteries – impeding circulation, increasing the necessary pumping effort.

With pipelines, fortunately, there's a quick remedy. Full efficiency can be restored through cleaning by chemical circulation, using Oakite methods and materials ... getting the benefit of Oakite ECP.

What's ECP? It's an Engineered Cleaning Program that takes into account your own individual soil problems, your requirements, your equipment. The Oakite Engineer lends personal and experienced supervision to the program, insures that the job is done at lowest possible cost.

Call your local Oakite man now. There's no obligation, of course. Meanwhile, for more information, write to Oakite Products, Inc., 51A Rector St., New York 6, N.Y.

OAKITE

in our 50th year

Export Division Cable Address: Oakite

Technical Service Representatives in Principal Cities of U. S. and Canada

logly, who has been with the company 29 years succeeds E. Frederick, who recently retired.

Gail E. Spain

J. R. Munro

W. K. Cox

L. L. Morgan

Caterpillar Tractor Co. Promotes Three Executives

The promotion of three executives is announced by Caterpillar Tractor Co. Vice president Gail E. Spain has been named president, Foreign Trade Group; J. R. Munro, director of manufacturing for foreign operations, has been made a vice president; and W. K. Cox, manager of sales promotion, was named a vice president.

Continuing as vice president of the company, Spain will administer Caterpillar's British, Australian, Brazilian and Canadian subsidiaries in addition to Caterpillar Americas Co., Caterpillar Overseas C.A., and Caterpillar of Delaware, Inc.

Spain has been with Caterpillar 28 years and a vice president 15 years. Munro, who has been with the company 40 years, will have administrative responsibility for the company's Manufacturing division. Cox, who has been with Caterpillar 30 years, succeeds Spain as vice president with administrative responsibility for domestic sales and sales promotion activities. L. L. Morgan, assistant manager, sales promotion, since 1956, will assume the position vacated by Cox.

W. H. Mouquin

William Porch

De Laval Opens Offices In New York City Area

The De Laval Steam Turbine Company and De Laval Separator Company have opened New York offices. W. H. Mouquin has been named manager of the Steam Turbine Company office, and William Porch is to head the New York district sales office for the separator company.

Mouquin joined De Laval in 1955 as manager of Chicago office. Porch has been with the company since 1945. He was named manager of Oil Purification division in 1952 and was appointed manager of Eastern division Industrial Sales in 1957.

Lewis L. Dollinger, Jr. Named President of Dollinger Corporation

Lewis L. Dollinger, Jr., has been named president of the Dollinger Corporation succeeding Lewis L. Dollinger, Sr., who becomes chairman of the board.

Lewis has been vice president and sales manager of the 37 year old firm which manufactures filters for all industrial and ventilating needs.

Roebling's Sons Corp. Names Wagner Philadelphia District Head

Charles A. Wagner has been appointed manager of the Philadelphia district, Wire Rope Division, John A. Roebling's Sons Corporation. Wagner has been with the company for the past 10 years, and has served as sales representative in both the New York and Philadelphia territories before being named assistant manager of sales in 1952.

C. A. Wagner

Prior to his new appointment he had supervised sales of wire rope slings and assemblies.

CLASSIFIED ADVERTISING

CHIEF PIPELINE ENGINEER
$20,000

Require grad. engineer, to 45, with substantial experience in design of pipe lines and in supervision of construction, from wells to port or refinery. Must be competent to contact important oil producers, prepare proposals, direct design and supervise installations.

Prefer man with some foreign experience and with language facility such as Spanish, French or German.

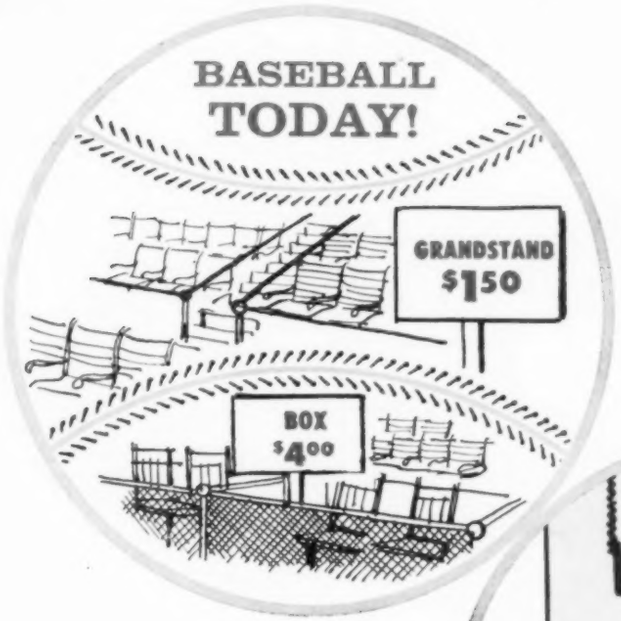
GAS PIPELINES ENGINEER
$12 - $15,000

Grad. Engineer, age 35-45, experienced in complete design of gas pipelines, supervision of engineering staff and of construction operations.

We are acting for a client.

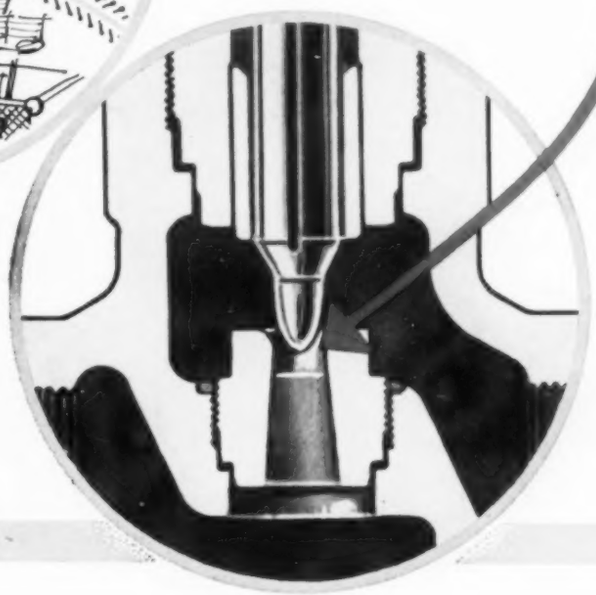
If eligible, send resume in DUPLICATE covering age, education, experience and availability, for confidential appraisal.

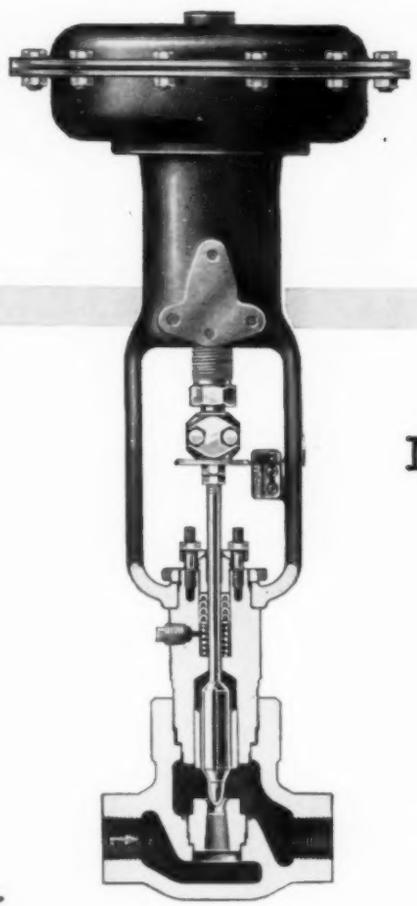
WALLACE CLARK & CO., INC.
Management Consultants—Est. 1920
521 Fifth Ave., New York 17, N. Y.



But...

No extra charge for this seat





NOW YOU GET STELLITE FACED SEATS ON ALL "D" BODIES

Now, for the first time, Fisher places Stellite on the facing of the seat ring and inner valve in high pressure "D" Bodies at no extra cost. This extra measure of protection resists erosion due to sand, foreign matter or high pressure—greatly increases life of regulator under adverse service conditions.

Available for working pressures up to 6000 pounds in sizes ½" through 2". 1" and 2" sizes, however, can be supplied when required for pressures up to 10,000 pounds. Also available in angle bodies (Type 667-DA) in sizes of 1" through 2" with working pressures up to 6000 pounds.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD... CHANCES ARE IT'S CONTROLLED BY...

FISHER GOVERNOR COMPANY

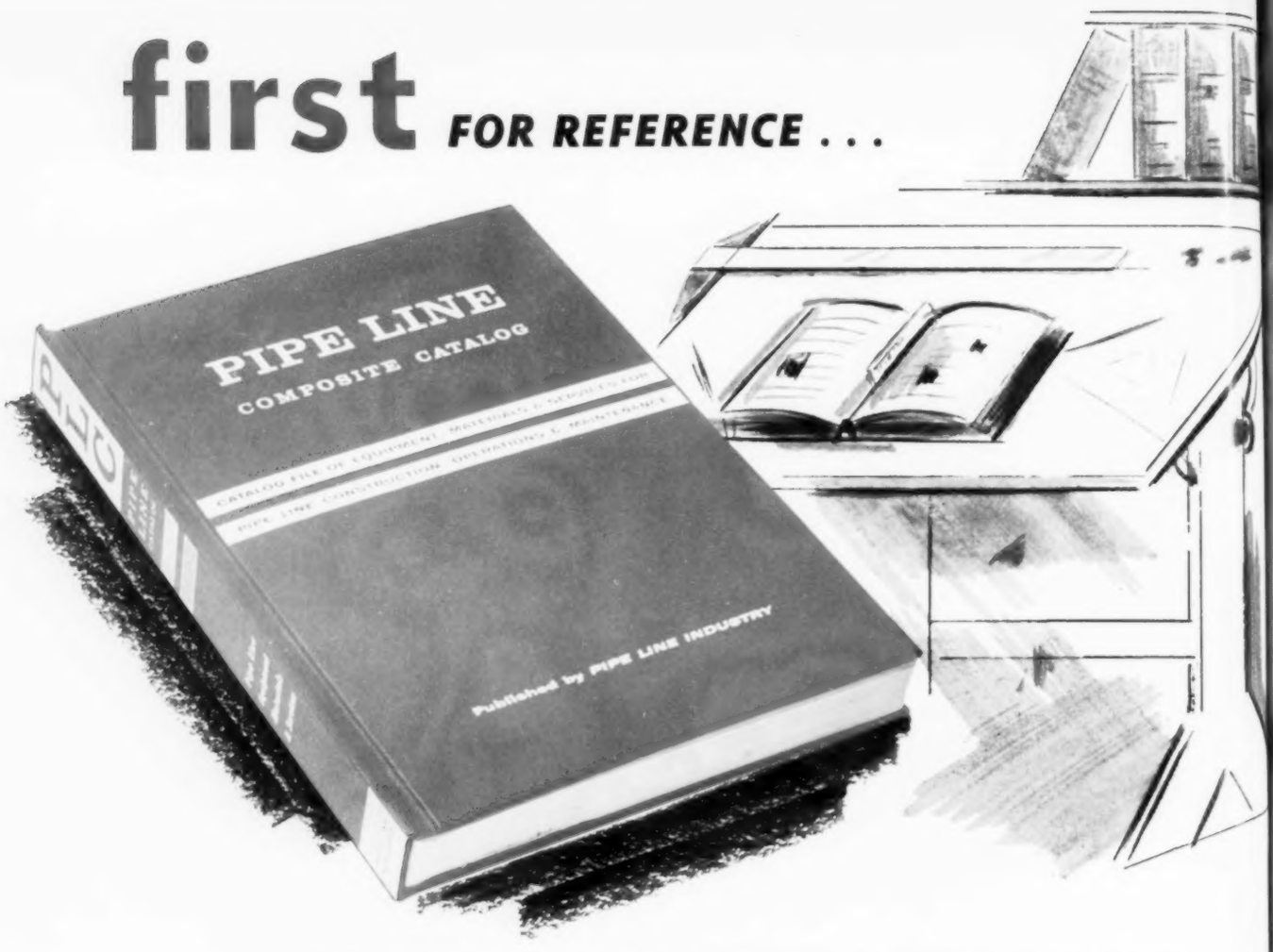
Marshalltown, Iowa / Woodstock, Ontario / London, England

FISHER® Controls

SINCE 1880

For more data on advertised products, use Readers' Service Cards, last page.

first *FOR REFERENCE . . .*



A one-volume reference library for purchasing and specifying. That's the best way to describe the only comprehensive catalog data file published specially for the Pipe Line Industry. Convenient to handle, thoroughly indexed, it is saving time and money for thousands of pipe line men.

first *FOR INFORMATION ON MANUFACTURERS AND SERVICE COMPANIES*

Included in 147 equipment and service company data in PLCC, there are 1,627 manufacturers' representatives and sources of supply listed.

first *FOR INDIVIDUAL EQUIPMENT AND SERVICE ITEMS*

There are 11,148 items of equipment and service items cataloged, with detailed information on specifications, installation, operation, maintenance, service—an entire library of useful reference.

first *FOR CONSTRUCTION EQUIPMENT AND SERVICE*

Pipe Line construction and service items listed in PIPE LINE COMPOSITE CATALOG total 390 . . . an invaluable aid to office and field specifications and purchases.

When you are ready to buy or specify, or if you just want planning information, look first in PIPE LINE COMPOSITE CATALOG.

ACF Industries, W-K-M Division
The Aerotec Corp.
M. N. Aitken Co.
Alco Products, Inc.
Aldrich Pump Co.
Allied Chemical & Dye Corp., Barrett Division
Allis-Chalmers
Alston Manufacturing Co.
American Blower Division of American-Standard
American Cyanamid Co., Jefferson Chemical Co. Subsidiary
Anchor-Wate
Automatic Power Inc.

Barber-Greene Co.
Barrett Division, Allied Chemical & Dye Corp.
J. B. Beaird Co., Inc.
Berry Hydraulics, Oliver Tyrone Corp.
Bethlehem Supply Co.
Bettis Corp.
Books for Pipe Line Industry
Borg-Warner Corp., Byron Jackson Div.
Bramble Industries, Gulf States Asphalt Co. Division
Bucyrus-Erie Co.
Buffalo-Eclipse Corp., Penberthy Manufacturing Co. Division
G. T. Bynum Co.
Byron Jackson Pumps, Inc., Subsidiary of Borg-Warner Corp.

E. L. Caldwell Co.
Philip Carey Mfg. Co.
Caterpillar Tractor Co.
Cathodic Protection Service
Central Plastics Co.
Clark Bros. Co., One of The Dresser Industries
Coffing Hoist Division, Duff-Norton Co.
Colorado Fuel and Iron Corp., Wickwire Rope Division
Commercial Iron Works
Cook Bros. Equipment Co.
C. Lee Cook Co., Division of Dover Corp.
Corrosion Rectifying Co., Inc.
G. A. Cotten Co.
M. J. Crose Manufacturing Co., Inc.
Crutcher-Rolfs-Cummings, Inc.

Darling Valve & Manufacturing Co.
John Deere—Industrial Division
Dover Corp., C. Lee Cook Co. Division
Dresser Industries, Clark Bros. Co. Division
Magnet Cove Barium Corp. Division
Drive-Thru Gate Co.
Duff-Norton Co., Coffing Hoist Division
Dutch Brand Division, Johns-Manville Corp.

Allan Edwards, Inc.
Elliott Co., Ridgway Division
Embart Manufacturing Co., The Maxim Silencer Co. Subsidiary
Engineering Research Corp.

Falk Corp.
Farrel-Birmingham Co., Inc.
Federal Telephone and Radio Co., Division of International Telephone and Telegraph Corp.
Fish Engineering Corp.
Flexitallic Gasket Co.
Fluor Products Co., Division of Fluor Corp., Ltd.

Gardner-Denver Co.
Gaso Pump & Burner Mfg. Co.
Gearench Mfg. Co.

These leading manufacturers, suppliers and service companies have filed complete or condensed catalog data in the current edition of the new PIPE LINE COMPOSITE CATALOG. See their detailed information in the catalog when you are ready to buy.

General Electric Co.
The Gorman-Rupp Co.
Granberg Corp.
Greenhead Sling and Supply Co.
Greenwood Valve Division, Vernon Tool Co., Ltd.
Grove Valve and Regulator Co.
The Gulf Publishing Co. (Pipe Line Forms)
Gulf States Asphalt Co., Division of Bramble Industries

H & L Tooth Co.
H & M Pipe Beveling Machine Co.
Hamer Valves Inc.
Hammond Iron Works
Haynes Manufacturing Co.
Hercules Motors Corp.
Holcombe Co., Inc.
Homelite, Division of Textron Inc.
Houston Equipment Co., Inc., Division of Houston Foundry & Machine Co.
Hudson Engineering Corp.
Humble Oil & Refining Co.
Hydril Co.

Ingersoll-Rand Co.
International Telephone and Telegraph Corp., Federal Telephone and Radio Co. Division

Jefferson Chemical Co., Subsidiary of American Cyanamid Co.
Johns-Manville Corp., Dutch Brand Div.

King Tool Co., Ltd.
Kinzbach Tool Co., Inc.

L & M Company
L-K Pump Valve Co.
Ledeen Mfg. Co.
LeRoi Division, Westinghouse Air Brake Co.
Lloyd Metal Foundry
Lubrikup Co., Inc.
Lufkin Foundry & Machine Co.

Magnet Cove Barium Corp., One of the Dresser Industries
Magnetrol Inc.
S. N. M. A. R. E. P.
Marsh Instrument Co.
Mason-Neilan Division of Worthington Corp.
C. A. Mathey Machine Works, Inc.
Mavor-Kelly Co.
Maxim Silencer Co., Subsidiary of Embart Manufacturing Co.
McFarland Engineering & Pump Co.
McFarland Manufacturing Corp.
McKissick Products Corp.
Mercoid Corp.
Midwestern Pipe Line Products Co.
Mine Safety Appliances Co.
Mixing Equipment Co., Inc.
Modern Motors Sales & Service
Morris-Young-Owens Co.
Mountain States Asphalt Co., Division of Bramble Industries

Multiple Corp.
Frank W. Murphy, Manufacturer, Inc.

National Cylinder Gas Co., Tube Turns Division
National Tank Co.
Naylor Pipe Co.
Nickles Machine Corp.

Oliver Tyrone Corp., Berry Hydraulics
Oil Well Supply Division, United States Steel Corp.

Panellit, Inc.
Peerless Manufacturing Co.
Pelican Supply Co., Inc.
Penberthy Manufacturing Co., Division of Buffalo-Eclipse Corp.
Perrault Equipment Co.
Petrolite Corp., Tretolite Co. Division
Pipe Line Development Co.
Pipelife Corp.
Pittsburgh-Des Moines Steel Co.
Plyon QX, Modern Motors Sales & Service
Porter Co.
Potter Aeronautical Corp.
Protecto Wrap Co.
Pye Telecommunications Ltd.

Quality Marsh Equipment Co., Inc.

Ramsey Winch Manufacturing Co.
Reilly Tar & Chemical Corp.
Remco Manufacturing Co.
Ridgway Division, Elliott Co.
Rochester Manufacturing Co., Inc.

Schramm, Inc.
SHMCO Valves Inc.
M. B. Skinner Co.
Snelling Manufacturing, Inc.
Southern Mill & Manufacturing Co.
Sprague Engineering Corp.
Staytite Co.
D. E. Stearns Co.
N. C. Stearns Co.
Steel Forgings, Inc.
Superior Equipment Co.

Taylor Instrument Companies
Textron Inc., Homelite Division
Thermix Corp.
Thornhill-Craver Co., Inc.
Tinker & Rasor
Tretolite Co., Division of Petrolite Corp.
John D. Trilsch Inc.
Tube Turns, Division of National Cylinder Gas Co.

United States Motors Corp.
United States Steel Corp., Oil Well Supply Division

Vernon Tool Co., Ltd., Greenwood Valve Division
J. H. H. Voss Co., Inc.

W-K-M Division of ACF Industries, Inc.
E. H. Wachs Co.
John Waldron Corp.
Waukesha Motor Co.
Westinghouse Air Brake Co., LeRoi Division
Frank Wheatley Pump & Valve Mfr.
White Diesel Engine Division, The White Motor Co.
Whitmor Homebuilders, Inc.
Wickwire Rope Division, The Colorado Fuel and Iron Corp.
Wilkinson Products Co.
Worthington Corp.
Worthington Corp., Mason-Neilan Division

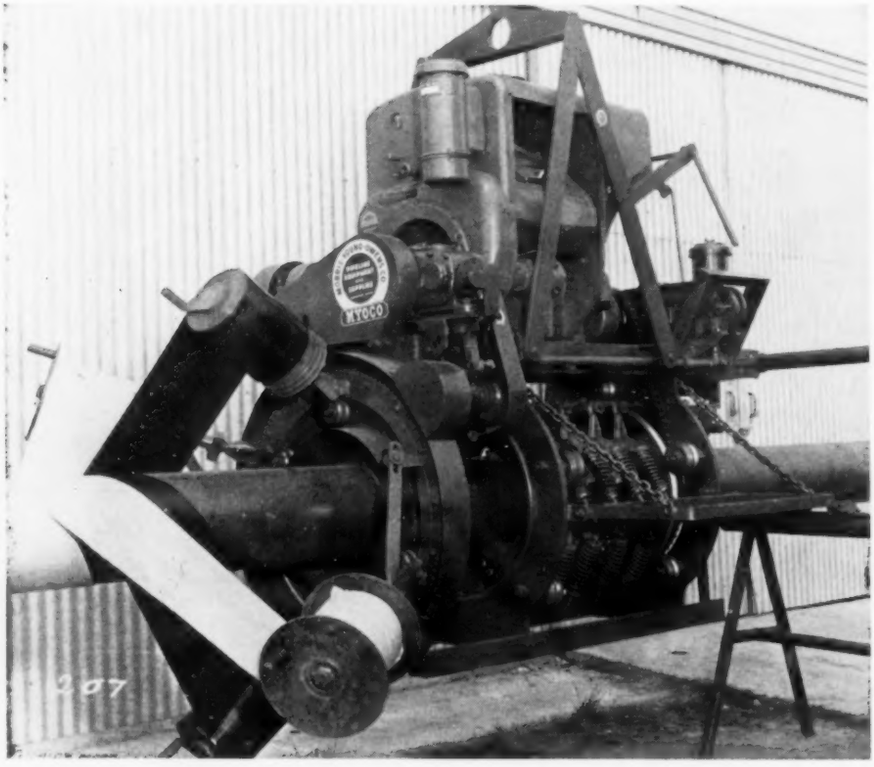
Yale Machine Works

PIPE LINE COMPOSITE CATALOG

Published by PIPE LINE INDUSTRY

P. O. BOX 2608 **HOUSTON, TEXAS**

What's New in EQUIPMENT



Taping, Cleaning Machine

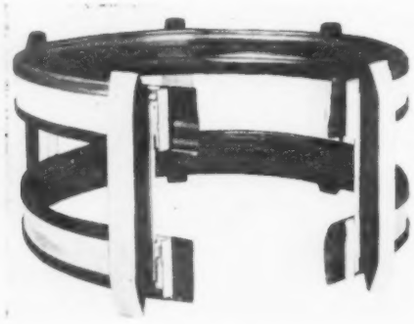
Morris-Young-Owens Company announces the latest power-driven taping and cleaning machine. It can be used to apply any combination, tape, felt, kraft, paper or any other wrap to pipe.

The machine is equipped with a PIV unit to adjust any lap desired from ¼ inch up. It also has a blower to blow dust and rust from the pipe and provide a clean surface for the tape.

The taping and cleaning machine has already been used successfully by many pipe line companies.

(This item supplements Morris-Young-Owens Co., data on Pages 296-297 of the Pipe Line Composite Catalog, 1st Edition.)

For more data, circle **No. E1** on Readers' Service Card, last page this issue.



Casing Seal and Cradle

F. H. Maloney Company announces the Model 58 full encirclement cradle and a new molded casing seal for pipe line construction work.

The Model 58 cradle supports the carrier end all around the diameter. It consists of two bands of steel, 2 inches wide, with an over-all width of 7 inches. Ribbed rubber lining on the bands provides double insulation and protection to the pipe coating and built-in tension allows installation without bolting. With the cradle installed, backfill cannot displace the carrier against the casing in any direction.

The rubber compounds casing seal is designed to withstand abrasion from backfill during construction. Triple thick walls at shear and pressure points eliminate the need for special rock shielding of the seal. A double convolute in the bellows section of the seal allows ample room for eccentric installations.

For more data, circle **No. E2** on Readers' Service Card, last page this issue.

Shut Down Alarm

Designed for the purpose of shutting down the compressor in case the lubricator stops rotating or the oil level drops in the reservoir, Manzel Division, Houdaille Industries, Inc., has developed a level-shaft rotation alarm.

A small Manzel pump, a bleed down chamber and a pressure switch actuated by pressure in the bleed down chamber are the components of the unit.

The alarm is offered as optional equipment for Manzel's number 82, 94 and other force-feed lubricator models.

For more data, circle **No. E3** on Readers' Service Card, last page this issue.

Gear Operated Valves

Rockwell Manufacturing Company has developed a gear operator which adapts wrench operated valves to gear operation. It has a 5-1 gear ratio and a 4-1 mechanical advantage; one turn of the wrench or handwheel will close or open the valve.

The gear operator fits directly over the square plug stem and down over the body of the valve. Special wrenches or handwheels are not needed since the wrench normally used will fit easily over the operating pinion.

Attachment may be done by one man. Installation requires tightening of a set screw on the valve plug stem and adjustment of two top screws which lightly contact the packing injector box. The plug stem projects through the gear operator, causing no interference with the valve's lubricating fitting. The assembly is offered in three sizes.

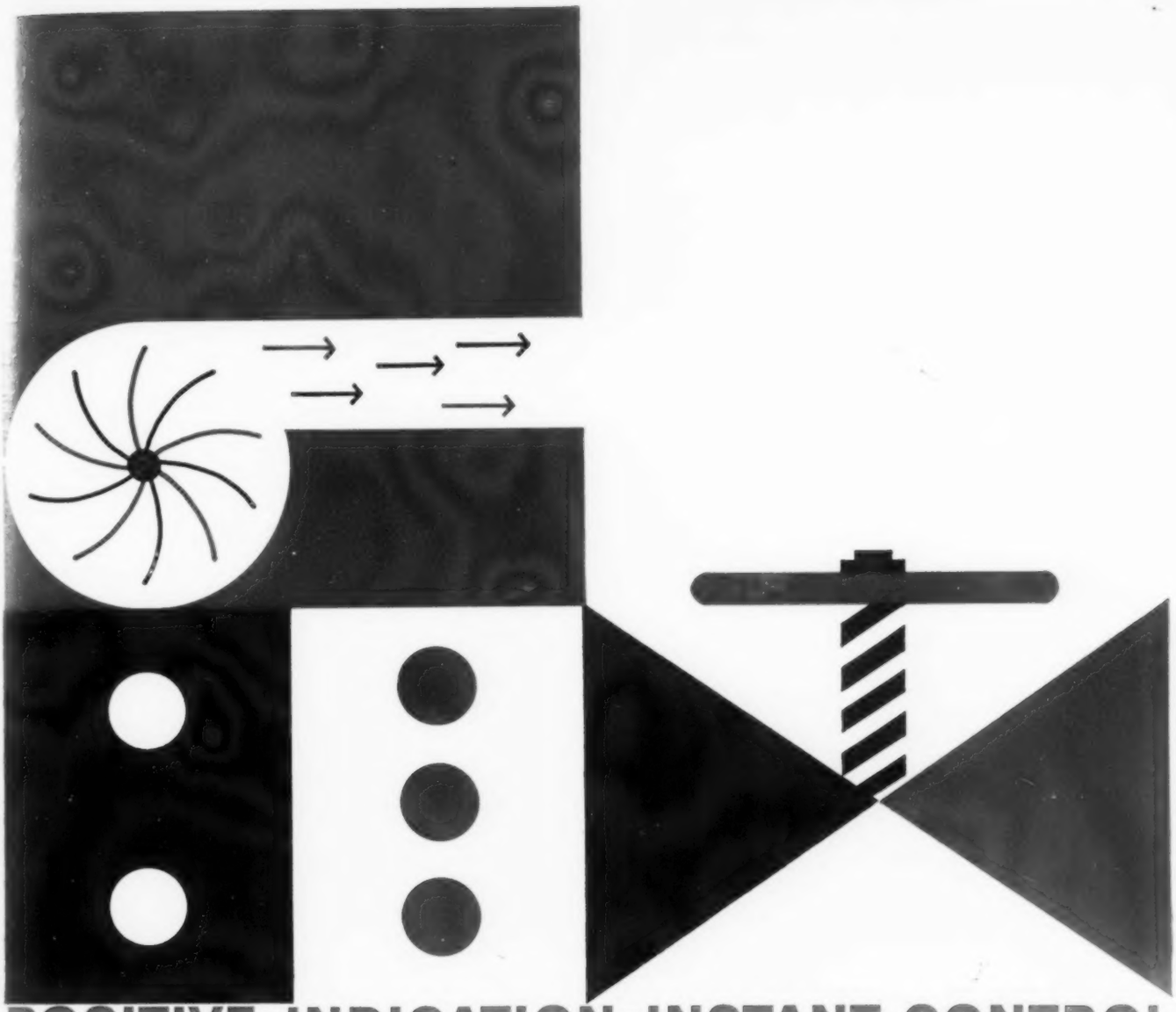
For more data, circle **No. E4** on Readers' Service Card, last page this issue.

Front Mounted Winch

A front-mounted winch and mounting kit for 1958 Chevrolet trucks is offered by Tulsa Winch division of Vickers, Inc. The Model F5C is rated at 7,500 pounds line pull with breaking point approximately 15,500 pounds. Including rollers and brackets it weighs 112 pounds.

The F5C winch and mounting kit includes all parts necessary for installation such as mounting brackets, cap screws and vertical and horizontal rollers.

For more data, circle **No. E5** on Readers' Service Card, last page this issue.



POSITIVE INDICATION-INSTANT CONTROL OF REMOTE PUMP MOTORS AND VALVES

S&J Gardtrol units continuously report actual conditions at remote points. They also allow instant change of conditions by the operator. Gardtrol Valve Monitor shows open, opening, closing, closed or stopped (partly closed) conditions. Gardtrol Pump Motor Monitor indicates on or off. Both have simple illuminated push button controls for all functions. Only one small wire—plus a common return—is needed between control unit and the field unit. S&J Gardtrol assures reliable supervisory control at lowest cost.

SHAND AND JURS | GPE

SHAND AND JURS COMPANY 2600 Eighth Street, Berkeley, California

A Subsidiary of General Precision Equipment Corporation

Branch offices and representatives in principal cities

Chain Saws

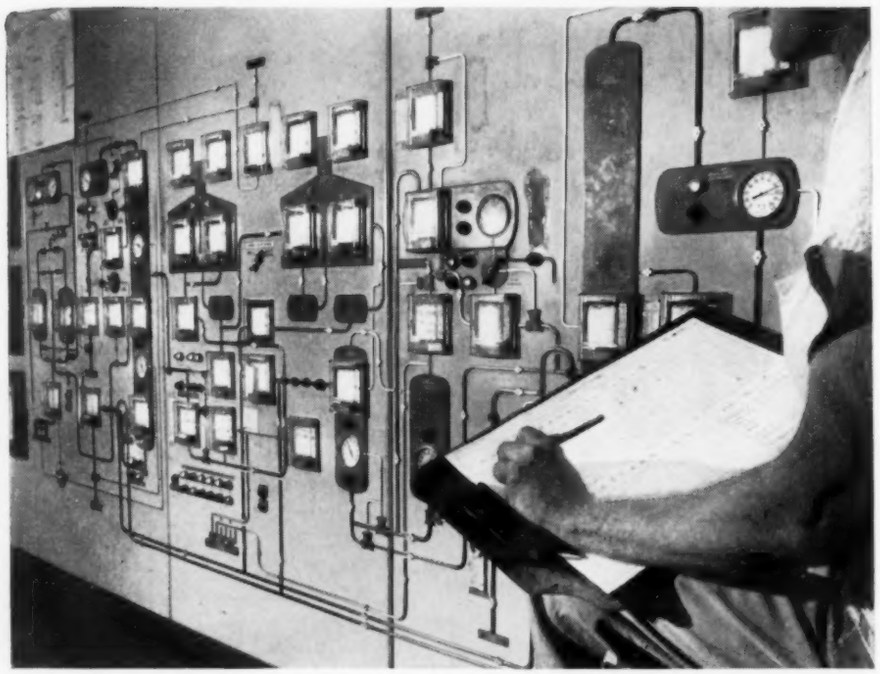
Two light weight, powerful, and well balanced chain saws, have been announced by Homelite, a division of Textron Inc. Model 7-19 is a direct drive 19-pound saw with enough power to cut down trees up to 5 feet in diameter. Straight blades, in sizes 12 to 30 inches, as well as plunge cut bow and brushcutter attachments are available.

A gear drive Model 7-21 weights only 21 pounds and will fell trees up to 7 feet in diameter. Straight blades for the 7-21 model are available from 14 to 60-inches as well as the plunge cut bow, brushcutter and clearing bar attachments.

Features included in the new models are: new Cylinder design providing 12 percent more cooling area, new balanced drop forged, steel alloy crankshaft with double row ball bearings on the clutch end and a caged needle bearing on the magneto end, plus high compression short stroke engine.

(This item supplements Homelite data on Pages 224-225 of the Pipe Line Composite Catalog, 1st Edition.)

For more data, circle **No. E6** on Readers' Service Card, last page this issue.



To keep 'em reading right . . .

Come to Kemp

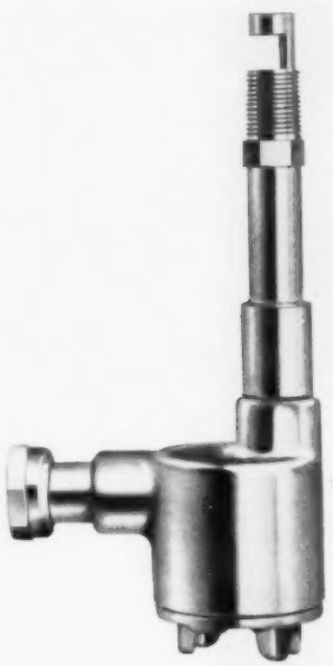
Get increased precision and longer life by protecting your air-operated instruments with Kemp Oriad Dryers. Kemp dryers clean and desiccate air supplies to stop condensation, corrosion and jamming.

In operations across the country, Kemp Oriad Dryers are giving dependable performance, year after year, with only routine care and maintenance.

Your Kemp Representative will show you how *your* instruments can get maximum protection at minimum cost. Or write us direct for Bulletins D-102 and D-103. The C. M. Kemp Mfg. Co., 405 E. Oliver St., Baltimore 2, Md.

KEMP OF BALTIMORE

Available in all sizes for automatic, semi-automatic, or manual operation. Steam or electric reactivation.



Liquid Sensor

Betatrol, a unique liquid level sensor, has been introduced by the Aeronautical and Instrument Division of Robertshaw-Fulton Controls Co.

The sensor utilizes a radioactive material in the sensing element designed to provide an actuating signal to control or indicate a predetermined level. Betatrol consists of a small sensing probe mountable in any altitude, that may be connected by up to 200 feet of cable to any amplifier.

A relay in the amplifier may be used to operate remote warning devices or motor starters, valves, timing devices and other mechanisms which may be used to maintain a desired liquid level.

For more data, circle **No. E7** on Readers' Service Card, last page this issue.

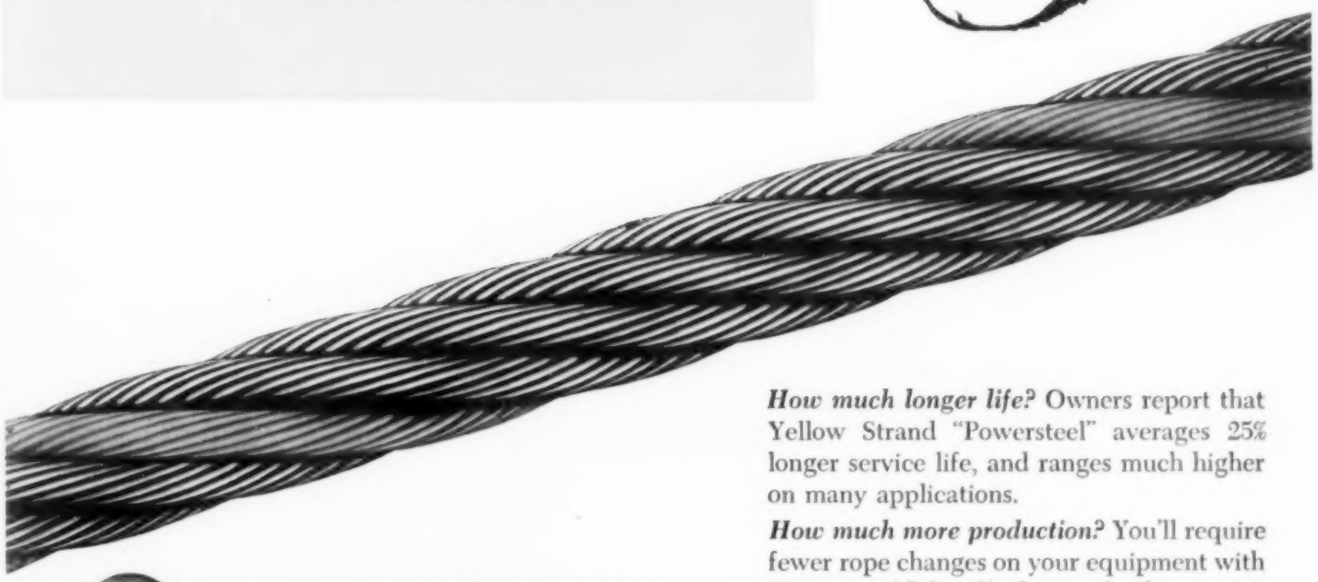
"POWERSTEEL"®

WIRE ROPE

PAYS OFF

Longer Life

Higher Production



How much longer life? Owners report that Yellow Strand "Powersteel" averages 25% longer service life, and ranges much higher on many applications.

How much more production? You'll require fewer rope changes on your equipment with "Powersteel," handle bigger loads, operate larger machines. You'll get greater production and more profit . . . less "downtime" and lower operating costs!

"Powersteel" is an extra high-strength rope for heavy loads and abrasive conditions. It spools freely, resists wear and crushing, and was developed for your high speed, high production equipment.

Your nearby Broderick & Bascom Distributor stocks an ample supply of Yellow Strand "Powersteel." See him for complete details. Broderick & Bascom Rope Co., 4203 Union Boulevard, St. Louis 15, Mo.

NEW! YELLOW STRAND WIRE ROPE CLIPS . . .

Ask for them at your Yellow Strand Wire Rope Distributor. Heavy-duty galvanized steel U-bolt. Drop-forged steel saddle, hot dip galvanized. Easily applied.

Yellow Strand®

Quality WIRE ROPE since 1876

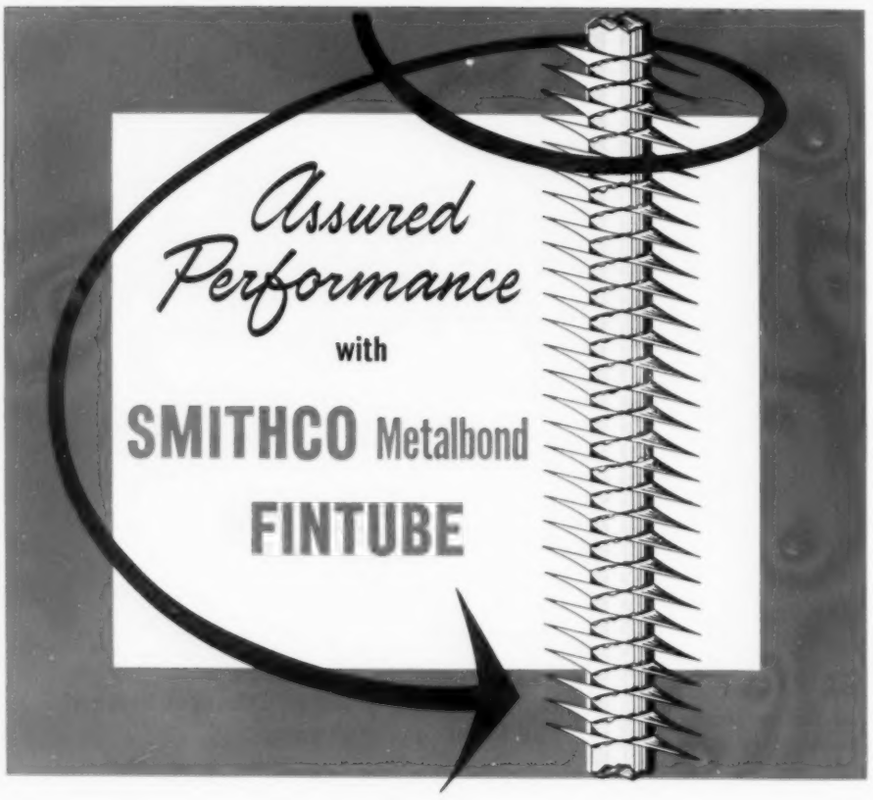
For more data on advertised products, use Readers' Service Cards, last page.

Maintenance Trailer

Stahl Metal Products Company announces a maintenance and construction trailer equipped with several compartments for carrying tools and materials to and from the job.

The theft proof trailer includes flush door handles and locks, keyed alike; an adjustable running gear which makes it easy to attach the trailer towing ring to a passenger car or truck for towing. An adjustable rear jack stabilizes the trailer when parked on the job and interior space provides a cushioned seat arrangement for seating three men. It is equipped with a heavy duty pipe vise bracket at rear, and sufficient inside light is provided by windows on each side of roof.

For more data, circle **No. E8** on Readers' Service Card, last page this issue.



METAL TRANSFERS HEAT MORE THAN 50,000% BETTER THAN AIR!

In mechanical bond finned tubes an air gap is always present between the fin and the tube which greatly reduces efficiency. Heat expansion loosens this bond and creates an even larger air gap which further retards heat transfer.

Air gaps are avoided in Smithco Air Cooled Heat Exchangers by employing metal as the bonding agent. This metal bond provides a smooth, unbroken flow of heat from tube to fin. Smithco *Metalbond* also protects against corrosion and has proven to be the most permanent bond yet devised.

☆ It's a SMITHCO . . . Your Guarantee of Quality

SMITHCO
Engineering Inc.

P. O. BOX 3217
TULSA, OKLAHOMA

Batch Control Injector

An automatic injector unit to control batch proportioning in pipe lines has been introduced by Granberg Corporation. This pump-meter combination permits homogeneous on-stream blending and has many potential uses such as feeding lubricants and treating industrial wastes.

A rotary positive displacement meter accurately records the total gallonage and energizes the pump at intervals, automatically injecting a controlled amount of additive into the batch. The injector pump is a double-acting piston type, that injects a uniform amount of liquid on each stroke of the piston. It operates at pressures up to 100 psi and at capacities from zero to 50 cubic inches per 100 gpm.

The injector unit can be operated with the pump remotely installed at any distance from the meter, or with pre-control and counter mounted directly to the injector unit.

(This item supplements Granberg Corporation data on Page 178 of the Pipe Line Composite Catalog, 1st Edition.)

For more data, circle **No. E9** on Readers' Service Card, last page this issue.

Turbine Engine Helicopter

Vertol Aircraft Corporation has developed a new model helicopter designed to take advantage of free-shaft turbine engines now in advanced stage of development. The Vertol 107 is powered by two Lycoming T-53 engines that deliver 825 horsepower each.

The new model can fly under most conditions with only one of its two engines, providing greater operational capability than earlier models powered by a single

UNICOR® keeps corrosion from eating a big hole in your profits

Talk about money down the drain! Look at the ways corrosion can lose you money:

1. Reduced flow capacity means less volume handled per day. Corrosion in your pipeline takes up money-making space, reduces C factor and output.
2. Filters cost money. Take a look at your filter replacement cost sheet for the past year and you'll see what we mean.
3. Downtime for filter cleaning and replacement is a dead weight on overhead. You're not making money when you're not on stream.
4. Equipment replacements aren't cheap, either. When corrosion takes over tanks and pipelines, you're out-of-pocket for new ones.

And now look at the ways UNICOR saves your money and your equipment:

1. Unicor is a film-forming, oil-soluble inhibitor that prevents all types of pipeline corrosion. Tanks, vessels, pipelines are protected whether full, half-full or empty.
2. Unicor increases C factor to a maximum, reduces power costs, filter replacements and scraping operations.
3. Unicor costs about $0.001 (one-tenth of a cent!) per barrel of product. One molecule of Unicor to one million molecules of product gives effective anti-corrosive action.

Stop corrosion and fouling. Save money and improve product quality. Specify UNICOR for any internal pipeline corrosion problems. If you'd like to evaluate UNICOR before you send an order, write for information and samples.

UNICOR® One of the family of superior UOP additives and inhibitors available to the petroleum industry

UNIVERSAL OIL PRODUCTS COMPANY

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More Than Forty Years Of Leadership In Petroleum Refining Technology

Joe Roughneck's solid source of supply...

API CASING | API TUBING | API LINE PIPE

Wheel of plenty! Welding pipe by electric resistance weld process. Lone Star API pipe is fully normalized.

Joe Roughneck, of course, is symbolic of the men who have made the fabulous oil and gas industry tick . . and Lone Star Steel's huge completely integrated plant is right in the middle of Joe's workshop. Lone Star pipe is quality-controlled from mining of ore to finished pipe. In addition to operating day and night to supply Joe's pipe needs . . Lone Star has recently completed new and even larger facilities.

Neighbor, wherever you are, specify Lone Star and we both get a good deal!

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Lone Star STEEL COMPANY

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DISTRICT SALES OFFICES
912 Republic National Bank Building, Dallas, Texas
Houston, Texas | Midland, Texas | Tulsa, Oklahoma

piston engine. It also has a higher performance and load carrying ability than light cargo helicopters now in operation.

The aircraft follows the tandem-rotor principle of earlier helicopters. It is shorter but has a larger cabin than the earlier models.

For more data, circle **No. E10** on Readers' Service Card, last page this issue.

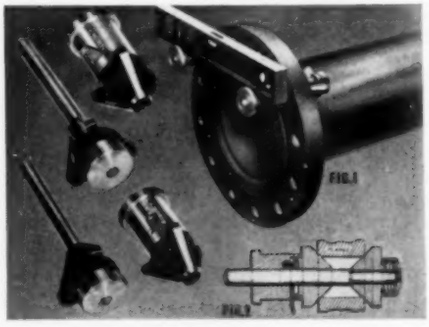
Quick Opening Closure

Sweco, Inc. announces a new quick opening closure for pipe line and station use. Now in use on scraper traps, blowdowns, and meter runs, the simplified closure is also designed for application on vessels, tanks, strainers and filters.

The Sweco closure is built to provide pipe line companies with a dependable closure that is easy to install, economical to maintain and completely safe and easy for personnel to open and close.

The unit comes completely assembled and only one field weld is necessary to attach it to the line. The door on the closure cannot open without absolute pressure relief; the yoke acts as a safety cage until completely spread.

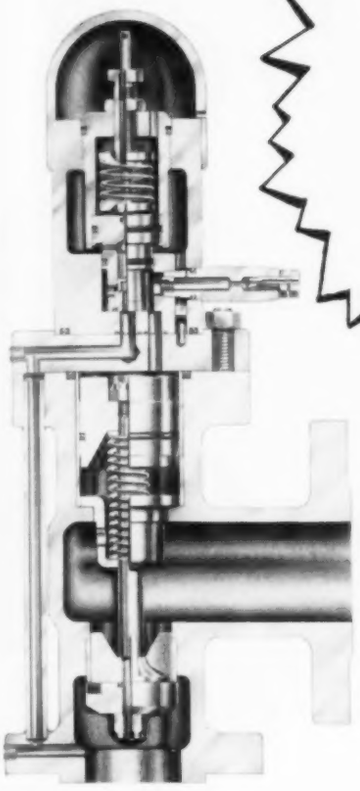
For more data, circle **No. E11** on Readers' Service Card, last page this issue.



Line-Up Pins

C. A. Mathey Machine Works, Inc., announces a new line of flange line-up pins for cutting and welding jigs for pipe line and fabrication.

The line-up pins fits ¼-inch to 1¾-inch bolt holes. Flange line-up pins are inserted in the holes of the flange and are perfectly horizontal preparatory to welding the flange to a pipe line.



INSTANTANEOUS OPENING FOR GAS OVERPRESSURES

MODEL 416 RELIEF VALVE ASSURES POSITIVE PROTECTION

The new pilot operated Kinzbach Model 416 Relief Valves were designed to be the most dependable relief valve for gas services. Whenever line pressure reaches set pressure the pilot valve opens and full line pressure is applied to the main valve, opening it through its full stroke without pressure accumulation.

This flat-seated pilot valve has a stainless steel loading spring which makes possible an extremely accurate set pressure and years of trouble-free performance. Some other advantages of this simple and rugged valve include its positive leakproof seating, easy functional testing below set pressure, and convenient bench setting for both opening and closing pressure. The Model 416 Valves are Certified under A.S.M.E. Unfired Pressure Vessel Code (Sec. VIII, Par. UG-131).

For complete details on this and other Kinzbach Relief Valves, write for new catalog.

KINZBACH TOOL CO INC

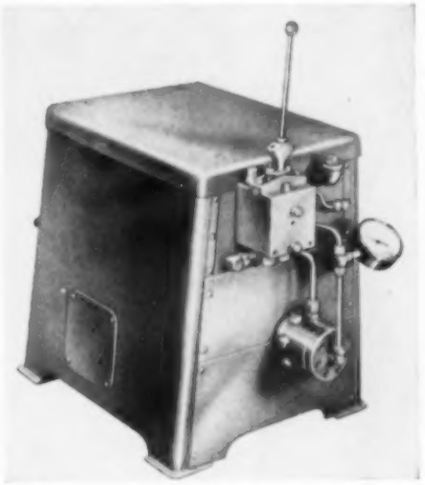
KINZBACH TOOL CO., INC.
P. O. Box 277 • Houston, Texas

EXPORT OFFICE:
74 TRINITY PLACE
NEW YORK, N. Y.

Cones of line-up pins automatically center the pin in any bolt hole and are designed to fit properly even on raised-face flanges.

(This item supplements C. A. Mathey Machine Works, Inc., on Pages 248-285 of the Pipe Line Composite Catalog, 1st Edition.)

For more data, circle **No. E12** on Readers' Service Card, last page this issue.



Hydraulic Pumps

Two hydraulic pumps to provide high volume at high pressure have been announced by the Owatonna Tool Co.

The pumps include a 6,000 psi pump with a two hp, AC 220-440 motor, which provides 220 cubic inches of oil per minute at zero pressure and 140 cubic inches at maximum pressure. The other is a 10,000 psis pump powered with a three hp, AC 320-440 motor providing the same oil flow per minute.

Both pumps are equipped with a three-position lever operated valve either for single or double acting rams and are fitted with filter pressure gage and two gallon reservoir all enclosed in a metal case.

This complete, high volume, high pressure power package provides faster operation of all hydraulic equipment such as presses, sprocket pullers, pivot shaft remover etc.

For more data, circle **No. E13** on Readers' Service Card, last page this issue.

Down-the-Hole Drill

A design change in Ingersoll Rand's down-the-hole drill provides continuous hole cleaning air even when the drill is not in operation.

Constant hole cleaning is available to keep hole clean and drill free even when it is necessary to stop drilling operations. Even with drill shut off, continuous high-pressure hole cleaning air passes through the drill and bit, keeping hole clean and minimizing sticking the drill in the hole. This also adds to the drill life.

All operating air is exhausted through the bit, therefore all air is used for hole cleaning. This eliminates the need for special exhaust ports in the side walls of the cylinder which can let harmful cuttings into the drill.

The drill is available in three sizes from 4¾ inches to 7 inches.

For more data, circle **No. E14** on Readers' Service Card, last page this issue.

whether you're **Mr. BIG**

or

Mr. Little...

YOU GET OUR UNDIVIDED ATTENTION!

We don't look upon our customers as Mr. BIG or Mr. LITTLE. We want your business . . . we are interested in your order whether it is large or small. All of our customers are VIPs. They receive the same prompt attention and service.

You don't have to *raise* KANE for service. We stand ready and able. Pipe, Casing, Pipeline Supplies, Pontoons, Piling, Field Welding — they will be on the job *when* and *where* you need it.

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Manufacturers of quality pipe for every purpose . . . . . .
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New Equipment Literature

For more data on New Equipment or copies of Catalogs and Literature reviewed in this issue, use the Reader Service postcards just inside the back cover and facing the Advertisers Index. Simply circle code numbers of items desired—sign and mail card.

Shovel-Cranes

Link-Belt Speeder Corporation has released a 24-page catalog covering the full 1-yard LS-98 shovel, crane, dragline and hoe. The illustrated booklet describes the LS-98 in detail from the crawler tracks to the upper machinery and the various front end attachments. The two-color catalog points out all the features of the machine. Power hydraulic controls, usable horsepower, independent swing and travel, attachments or modern manufacturing techniques are some of these features.

To get a copy, circle **No. E15** on Readers' Service Card, last page this issue.

Line Pipe

National Tube Division of United States Steel has issued a 32-page bulletin on line pipe. The highly illustrated, four color booklet covers all types of pipe describing, with photographs and illustrations, process of manufacturing seamless and expanded seamless pipe and electric weld pipe. It provides charts on weight, dimensions and test pressures on different kinds of pipe.

To get a copy, circle **No. E16** on Readers' Service Card, last page this issue.

Centrifix Scrubber

A technical data bulletin describing the Centrifix WD scrubber used to remove solid or liquid entrainment in gas or vapor is offered by Centrifix Corporation.

The illustrated four-page brochure presents cut-away views of two types of the WD scrubber: one equipped with spray ring, the other with an internal liquid feed. Its operation is described in detail, together with the five design variations that make possible the many different applications of this equipment in gas processing and transmission.

To get a copy, circle **No. E17** on Readers' Service Card, last page this issue.

Differential Producer

A 16-page folder to assist in selecting the proper differential producer for every flow metering situation has been released by Builders-Providence, Inc., division of B I F-Industries.

Contained in the booklet is a table which compares Builders-Providence metering devices in terms of such features as accuracy, range, life expectancy, initial and operating costs, recovery differential, weight, laying length etc.

To get a copy, circle **No. E18** on Readers' Service Card, last page this issue.

Splicing Techniques

Union Wire Rope Corporation has published a highly illustrated 38-page handbook on splicing techniques. The book is one of a series of educational handbooks available to help wire rope users.

The booklet covers various eye splicing methods, endless splices, performed and Lang Lay wire rope splicing and the Chicago technique. Subjects of grommets, socketing of ferrules and efficiencies of wire rope attachments are included. An engineers notebook on wire rope constructions and specifications is also presented.

To get a copy, circle **No. E19** on Readers' Service Card, last page this issue.

Lighting Fixtures

New explosion-proof and dust-ignition-proof mercury vapor lighting fixtures are described in a Crouse-Hinds bulletin. The two-page flier lists explosion-proof fixtures with five styles of reflectors, all available with or without guard. Two styles of dust-ignition-proof fixtures are listed.

The mercury vapor lamps provide high light output and long lamp life and are particularly useful where long hours of burning are common.

To get a copy, circle **No. E20** on Readers' Service Card, last page this issue.

Recording Annunciator

A four-page, two-color bulletin, which describes and illustrates the new model RA recording annunciator, has been released by Panellit, Inc.

The annunciator accurately records without complicated decoding off-normal and on-off operations, resulting in reduced operating costs, future downtime and maintenance in various industries concerned with temperature, pressure, flow and levels problems.

To get a copy, circle **No. E21** on Readers' Service Card, last page this issue.

Gas Turbine Motors

Clark Bros. Co. offers a six-page, illustrated catalog which describes the company's models 302 and 305 gas turbines. These 8,700-9,300 bhp units are used to drive pumps, generators and centrifugal compressors.

The catalog also discusses the principle design features, including specifications and a schematic diagram of the 305 model.

To get a copy, circle **No. E22** on Readers' Service Card, last page this issue.

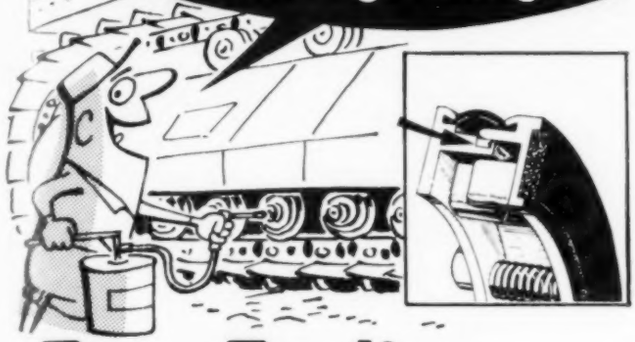
Direct Pipe Line Sampling

Precise automatic methods of sampling directly from pipe lines are described in an eight-page bulletin issued by Proportioneers, Inc., division of B-I-F Industries, Inc.

Illustrated with photographs and schematic drawings, the brochure describes technical aspects such as line stratification, flow profile, sample probe location and economic factors. Two basic methods —time-proportional and flow-proportional sampling—are explained, and various devices are analyzed.

To get a copy, circle **No. E23** on Readers' Service Card, last page this issue.

Sure-Seal® Protects Against Both Undergreasing and Overgreasing!



Sure-Seal® ROLLER SEALS

Undergreasing tractor rollers, for fear of breaking the seals, causes them to burn out. Sure-Seal Roller Seals solve that problem for you:

You can grease your rollers thoroughly with high pressure, even breaking grease-starving air locks, when you install Sure-Seal Roller Seals. An exclusive inner seal prevents the high pressure grease from reaching the outer bellows seal. Sure-Seals are also made for final drives. Ask your dealer about them. A complete line made for Caterpillar, International Harvester and Allis-Chalmers tractors.

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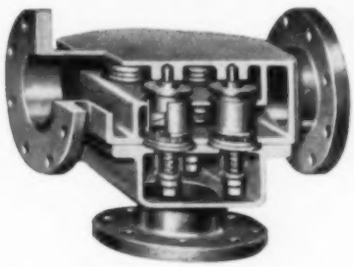
Sure-Seal Equipment Co.

1820 N. W. 25th Ave. • Portland 10, Oregon

AMOT Engine Controls



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- **THERMOSTATIC VALVES**
  For jacket water and lube oil temperature control.
- **MECHANICAL SAFETY CONTROLS**
  Shut down engine on high water temp. or low oil pressure.
- **SAFETY CONTROL SWITCHES**
  Sound alarms on high water temperature or low oil pressure.
- **VENTED DIAPHRAGM GAS VALVES**
  Shut off main gas supply to gas engines.
- **THERMOSTATICALLY ACTUATED AIR VALVES**
  For automatic fuel change over.

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Serving the Pipeline Industry

with Lincoln Arc Welding Supplies

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WELDING SUPPLY CO.
is happy to announce their appointment as
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DISTRIBUTORS FOR
TEXAS OKLAHOMA NEW MEXICO

PORTABLE ROTARY AIR COMPRESSORS
(Designed for the pipeline industry)

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CONTRACTORS TOOLS AND PUMPS
TURNING TOOLS AND
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DALLAS, ODESSA, LUBBOCK, BORGER
EL PASO, LONGVIEW, ALBUQUERQUE, FARMINGTON

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Railhead or in plant facilities apply coating rapidly, uniformly

Somastic® Coated Pipe is your permanent protection against corrosion

Central or railhead plants are available to you for the application of Somastic® Pipe Coating. It is *thick*. It is *seamless* . . . no holidays because of overlapping layers, or bubbles. It is *re-inforced*, permanently. It is *rigid yet elastic*. And . . . it is proven under adverse soil conditions for more than 25 years. Why not coat your pipe *the better way?*

Write for full information TODAY!

Specializing in Pipe Protection Problems
• Tate and Centriline "In Place" Interior Cement Mortar Lining • "In Plant" and "Railhead" Centrifugal Spinning of Cement Mortar or Coal Tar Linings — Somastic® Exterior Coating • Pipe Wrapping • Reclamation: Removal of Old Wrapping, Straightening, Blasting, Beveling, Testing.

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A Division of American Pipe and Construction Co.
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Bob Wagner supervises all Somerville work in the U. S. and Canada

Assigned as head of all supervisory work for Somerville, Bob gives customers the benefit of his more than 20 years of practical field experience.

From cat driving to pipeline work in the Armed Forces, Bob has both the know-how and the executive ability to get your next job done right.

SOMERVILLE CONSTRUCTION CO.
Ada, Michigan
SIGN OF SATISFACTION
TRANSMISSION LINES — DISTRIBUTION SYSTEMS

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Union Wire Rope Corp. 16
• United States Motors Corp. 64
Universal Oil Products Co. 89

W

• W-K-M Division
ACF Industries, Inc. 79
Wilkening Manufacturing Co. 51

Y

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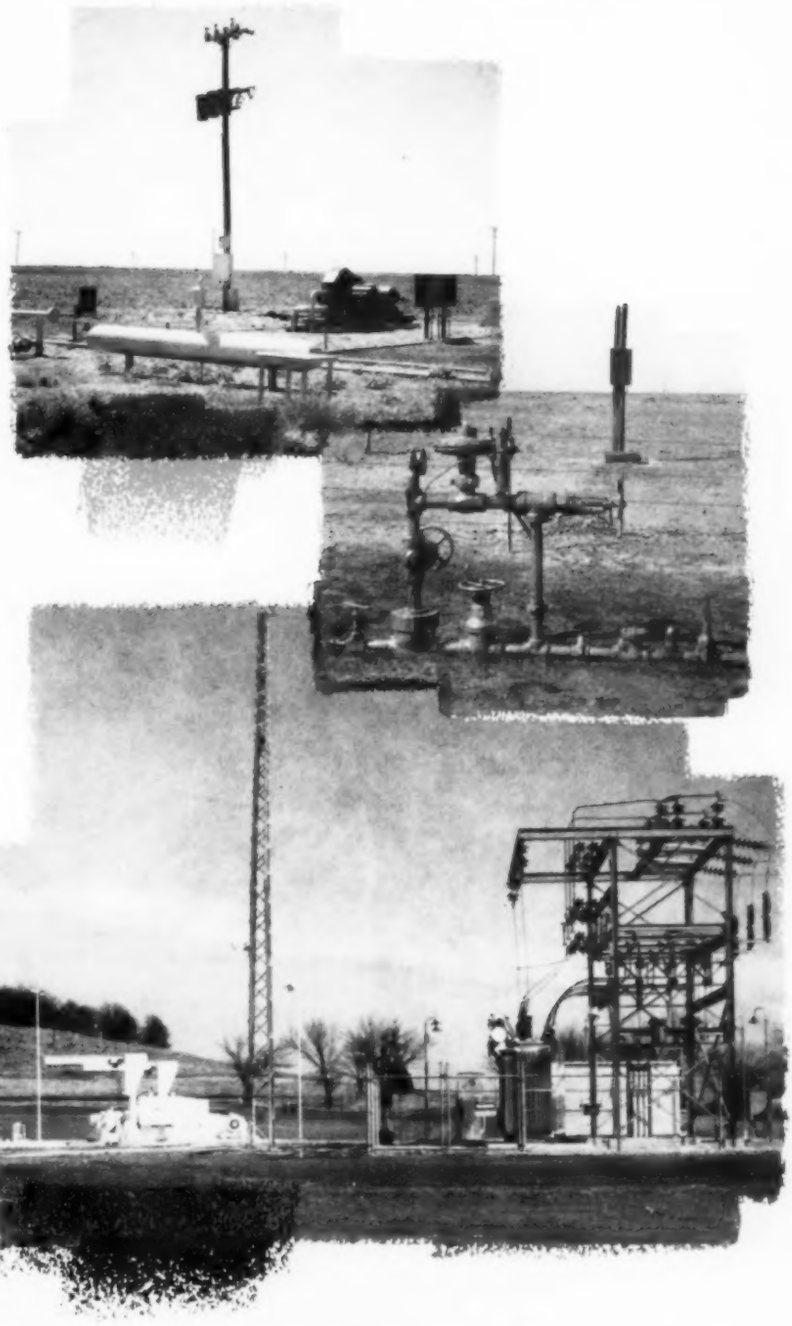
The remote controlled crude station pictured below is typical of modern application of low-cost Purchased Electric Power. A smaller remote controlled pipeline installation is shown at the top.

However, remote automatic electrical control may take a simpler form. The illustration at the right shows an electrically operated solenoid valve on a flowing well, controlled by an electric time clock. To take advantage of the many outstanding savings offered by Purchased Electric Power call your nearest Utility Electric Service Company or write us.



Remote controlled crude station with electrically controlled valves and sump pump

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